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Subjective disorientation as a metacognitive feeling

Pablo Fernández Velasco and Roberto Casati

ABSTRACT

There is a large body of literature on disorientation, ranging from behavioral studies to the analysis of search and rescue operations. However, the subjective side of disorientation remains insufficiently explored and, as a result, there is no unified account of the phenomenon. A working characterization of disorientation is a first step in the direction of this unified account. Through the study of an array of subjective experiences of disorientation, we shall first distinguish between the objective condition of *being lost* and the subjective condition of *disorientation*. Our central claim is then that disorientation is a metacognitive feeling. Specifically, we claim that disorientation is a metacognitive feeling of low confidence in the subject's online system of spatial representation.

KEYWORDS Disorientation; metacognitive feelings; getting lost; spatial cognition

1. Introduction

The literature on disorientation is not a unified body of research. Rather, there are many fields that deal with disorientation (Friedberg, 2017). The historical record is rich and variate, because coping with difficulties in orientation has been a major challenge in the history of navigation (Huth, 2013). Most of the recent data on human disorientation in real-life settings has been collected for the science of search and rescue operations through the study of lost person behavior (Koester, 2008; Lin & Goodrich, 2010; Sava, Twardy, Koester & Sonwalkar, 2016). Another large body of work comes from clinical psychology and from neurology, through the study of conditions such as topological disorientation or Alzheimer's disease (Henderson, Mack & Williams, 1989; Monacelli, Cushman, Kavcic & Duffy, 2003). The patients who suffer from topological disorientation have selectively lost their ability to find their way within large environments (Aguirre & D'Esposito, 1999). Work on disorientation has also been done in cognitive science and in psychology, including animal and developmental studies (Waller & Hodgson, 2006; see Dudchenko, 2010 for an overview of the literature). However, there still is a missing link that connects the work in these different fields. One possible reason for that is that while the work on lost person behavior (Hill,

1998) takes its input data from the cases of people getting lost in real situations (and most often in natural settings), the work in cognitive science tends to be simulation-based (Ruddle, Volkova, Mohler & Bühlhoff, 2011), and a large part of the work in psychology takes place in non-ecological conditions (Cheung, Ball, Milford, Wyeth & Wiles, 2012; Mou, Xiaoou, & McNamara, 2012).

This paper is organized as follows. In Section 2, we summarize some of the main relevant findings on disorientation, centering around the specifics of the vision-bound human orientation system. We then introduce some conceptual distinctions to orient the interpretation of the findings. Section 3 details our methodology, which makes use of real cases. We put the methodology at work by discussing a paradigmatic case of disorientation. In section 4, we explore less paradigmatic cases and we make a claim on the dissociation between feeling disoriented and being lost. Section 5 builds on this dissociation and discusses illusory feelings of orientation and disorientation. The central claim of this paper comes up in section 6, where disorientation is characterized as a metacognitive feeling. Disorientation is then discussed in the more general framework of theories of metacognitive feelings in section 7. Section 8 discusses the factors and effects of disorientation and section 9 contains our conclusions and some directions for future research.

2. Relevant empirical findings

In his book *Why people get lost* Dudchenko reviews existing research in behavioral psychology and neuroscience of humans and non-human animals. According to a large body of research, humans need vision to avoid getting lost. Thus, what underlies people getting lost is either a breakdown of their spatial representations (as could happen in a dark environment without nearby walls) or, for the most part, a failure in using visual landmarks, which serve to update one's orientation and position within a cognitive map (Scholl, 1987; Knierim & Hamilton, 2011). The existence of cognitive maps was first hypothesized by Tolman to explain the adaptive behavior of rats in labyrinths. Tolman observed how rats sample environments and how they find shortcuts that had not been learned through stimulus-response conditioning (Tolman, 1938, 1948). He concluded that rats construct something similar to a mental field map. In general, animal ability to find unlearned shortcuts and detours is best explained by positing possession of map-like internal representations.

The notion of a cognitive map gained neuroscientific support with the discovery of place cells, a set of cells in the rat's hippocampus that fire as a function of their spatial location (O'Keefe & Dostrovsky, 1971). Later, the discovery of grid cells, head direction cells and boundary vector cells further

supported the existence of cognitive maps, as these mechanisms are best interpreted as feeding map-like representations of space. Grid cells fire in a hexagonal grid that corresponds with the environment floor (Hafting et al., 2005). Head direction cells fire according to head orientation (Ranck, 1985; Taube et al., 1990). Boundary vector cells fire when the rat gets to a specific distance from an environmental boundary (Barry et al., 2006). In hindsight, the behavior of specialized cells can be interpreted as constraining the solution to the space representation problem: place, grid, head orientation and boundary cells provide individual, metric, angle and topological constraints respectively (Fernandez Velasco & Casati 2019). Dudchenko argues that, if the idea of a cognitive map can be extrapolated to humans (see Epstein et al., 2017 for a review of empirical literature supporting this extrapolation), it seems that visual landmarks play an important role in anchoring these cognitive maps (see Yoder, Clark, & Taube, 2011). This is because “the head direction, grid, and place cell systems can be re-set by salient landmarks” (p.252, Dudchenko, 2010). In other words, the head direction system tracks visual landmarks in order to update the subject’s location within a cognitive map.

An important distinction when considering disorientation is between a transient and dynamic *online system of spatial representation* and an enduring, *offline system of spatial representation* (Amorim et al., 1997, Wang & Spelke, 2000, Waller & Hodgson, 2006). Wang and Spelke wanted to test whether human navigation depends on transient and dynamic representations of the environment or on enduring cognitive maps. They got participants to learn the arrangements of objects in a room and then point to unseen targets, either oriented or disoriented (i.e. after having been disoriented through self-rotation), and found what they dubbed the “disorientation effect”: Disorientation impaired the participant’s absolute accuracy in pointing to all objects and the relative accuracy in pointing to different objects. In contrast, disorientation had only a small effect when participants were asked to point to the corners of the room, suggesting that while the spatial arrangement of objects within a room depends on transient spatial representations, room geometry depends on enduring spatial representations (Wang & Spelke, 2000).

Waller and Hodgson replicated the above experimental setting but added an extra task: they asked participants (in both oriented and disoriented trials) to judge the relative directions between different objects in the room, such as “Imagine that you are at the door, facing the TV; point to the fabric.” Interestingly, while they replicated the previous result that disorientation decreases pointing accuracy from the participant’s position, they found that disorientation actually increases inter-object pointing accuracy, which would not be predicted by Wang and Spelke’s hypothesis. In contrast, these results are consistent with the idea that during disorientation there is a change from

a relatively precise online representation to a relatively coarse enduring offline representation of the environment. In other variations of the experimental setting, Waller and Hodgson found support for the idea that changing between online and offline systems of spatial representation does not require disorientation, but can also be produced by self-rotations (experiment 3) and that the change between the two systems is better understood as a switch rather than as a gradual transition (Waller & Hodgson, 2006).

It is important to clarify that the distinction between online and offline systems of spatial representations is orthogonal to the distinction between egocentric and allocentric frames of reference (Pani & Dupree, 1994). While these two distinctions share some similarities, subjects use both egocentric (self-referenced) and allocentric (world-referenced) frames of reference to construct online representations during navigation. For instance, an allocentric frame of reference (e.g. an allocentric mental map of Manhattan) can be embedded into an online representation (e.g. a navigator can use the allocentric mental map of Manhattan to orient within the space around her in order to go from point A to point B).

3. Methodology

As we mentioned earlier, even if there have been recent important advances coming from research on spatial cognition, other fields that deal with the phenomenon of disorientation are only loosely connected to this body of research. As a matter of fact, there is no account of disorientation that unifies the different fields that deal with the phenomenon. A working characterization of disorientation is thus a first step in the direction of a unified conceptualization of disorientation. The difficulty is that such a characterization should ideally both spring from the subjective experience of disorientation and be constituted of non-subjective elements. Our approach to attain this difficult balance is to tackle head-on the subjective side of disorientation, which is often overlooked in the literature. The methodology consists in analyzing different subjective experiences of disorientation from a corpus of cases (hereon referred to as *scenarios*) that constrain a characterization of disorientation. Scenarios are based on pseudonymized real-life cases that have been gathered through online surveys, semi-structured interviews and direct reports. Scenarios are included insofar as they highlight the relevant dimensions of the phenomenon under study.

The corpus is in an early stage, but already advanced enough to provide a good reference for the study of disorientation. As of 17th February 2019, we had received 34 responses (after discounting blank and partially blank responses). 6 responses were excluded because they were not strictly about spatial disorientation, but about other forms of disorientation (e.g. temporal disorientation, existential disorientation ...). These were complemented by

a series of cases of disorientation that were reported directly (e.g. by people that were aware of the corpus) and then pseudonymized.

The survey asked subjects to report on a particular instance in which they felt disoriented. We then collected demographic data from subjects, and we asked them to rate a series of statements about their disorientation experience on a Likert scale (e.g. “the experience of disorientation made the environment feel unfamiliar”). Direct reports were particularly interesting in that the subjects reported about rather unusual cases of disorientation or about cases that were not quite core cases of disorientation but borderline cases (e.g. illusory feelings of orientation and disorientation, discussed in section 5).

The idea behind the development of our corpus of cases of disorientation is to have a body of reports that can help us make sense of the phenomenon and guide the conceptual work. We do not intend for the surveys and reports to be direct support for a given hypothesis but to further our general understanding of disorientation. Moreover, we have only chosen cases for this study that we deemed uncontroversial enough to ensure intersubjective agreement.

The development of a corpus of subjective reports is very much in line with work on spatial disorientation in particular and cognitive geography in general (see Montello, 2017 for cautions on the use of explicit reports in cognitive geography). In the context of disorientation, psychologist Alfred Binet collected subjective reports of people being “turned around” (i.e. the peculiar form of disorientation that ensues when one realizes that the spatial arrangement of an environment is 180° opposite to what one expected) (Binet, 1885, 1894) and Kenneth Hill collected reports of hunters getting lost in the forests of Nova Scotia (Hill, 1992).

To illustrate our methodology, we will begin by discussing a paradigmatic scenario of disorientation:

Scenario 1. Paradigmatic Disorientation Case. I was trying to look for a bookstore that I had gone to once in a mall. I only remembered the direction from the entrance to that bookstore but didn't remember the route exactly. When I arrived at a junction, I didn't know where to go next. I randomly chose a route and unfortunately it was the wrong way. I tried to use the interactive map in the mall, but it seemed like the map wasn't properly oriented and it referred to certain landmarks in the mall that I don't know about. I tried to go back to the entrance and find my way again. I succeeded the second time around.

In the above scenario, the subject is objectively lost and feels disoriented. She realizes not to be in the place she thought to be in. She chooses the wrong turn and finds herself in an unfamiliar place. She tries to use a map, but she is unable to interpret it. She managed to retrace her steps to the entrance. On the second time around, she manages to find her way to the bookstore and the feeling of disorientation evaporates. Our main tenet is that

the above paradigmatic scenario – modal as it may be – makes it difficult to disentangle the different aspects of disorientation. To bring into focus the extent of our characterization, in the next section we differentiate between ‘being lost’ (objective; third-personal) and ‘being disoriented’ (subjective; first-personal).

4. The misalignment between being lost and being disoriented

From the objective point of view, we can characterize being lost as the subject’s inability to find her way (even if eventually, the subject regains this ability). This is the characterization that Dudchenko offers in his book, and it does not require access to first personal data (Dudchenko, 2010). Whether the subject is able to find her way or not is evident or can be gathered from her behavior, and afterward, from whether the subject has succeeded or not in finding her way. Alternative objective characterizations of being lost include a failure of the way-finding process (Golledge, 1999) or not knowing the directions and distances to get to a given point (Rieser, 1999).

There is a potential epistemological issue with an objective categorization. Namely, that for determining whether the subject is objectively lost or not, we might need to ask them if they are subjectively disoriented. Nevertheless, the issue is of a practical rather than ontological nature. What matters for the purposes of this section is whether or not the subject is objectively lost, not how an external observer can know whether or not the subject is lost.

Furthermore, there are several examples of objective characterizations of being lost that lead to objective measures. For instance, in an early wayfinding study, Best defined the degrees of lostness as the deviations from the most direct route (Best, 1970). By their very nature, search and rescue missions also need to use an objective operational characterization of being lost – the lost person is of course declared lost (objectively, as search and rescue teams cannot ask the lost person directly) before the operation starts.

Other studies compare the choices participants make to the optimal choices available to measure lostness (Van den Berg, 2018) or use a hierarchical Dynamic Bayesian Network model to detect outliers in the subject’s GPS trajectories as potential instances of subjects being lost (Lin et al., 2015). Each separate objective measure of lostness has its potential pitfalls (e.g. following the most direct route might not be the most relevant criteria for subjects choosing their itinerary). For this reason, studies often try to find the objective measures of lostness that best predict subjective disorientation based on first-person reports (see Gwizdka & Spence, 2007 for an example in the context of lostness in web navigation). And a characterization of subjective disorientation is a necessary first step to understand the phenomenon that the study in question is trying to capture with different objective measures.

An objective characterization of being lost is orthogonal to the subjective characterization of disorientation. This means that a double misalignment can occur: a person can feel disoriented without being lost, and conversely, she can feel oriented when in fact she is lost. Below is a case-based matrix meant to disentangle the cases in which the objective and the subjective characterizations come apart (numbers refer to the scenarios in the text).¹

	<u>Subject feels disoriented</u>	<u>Subject does not feel disoriented</u>
<u>Subject is objectively lost</u>	Paradigmatic Disorientation Case (1)	Illusory feeling of orientation (2a)
<u>Subject is objectively not lost</u>	Illusory feeling of disorientation (3)	Paradigmatic Orientation Case

5. Illusions of orientation and disorientation

A good example of a ‘paradigmatic disorientation case’ is scenario number 1. It is not in the scope of this article to analyze orientation cases, but for a paradigmatic orientation case, the reader can pick up from the myriad that one finds in daily life. An everyday activity like going from one’s house to one’s favorite bakery and back is an example of a paradigmatic orientation case. What is of interest here are the other two cases: the occurrence of disorientation without the appropriate feeling, and of orientation with the inappropriate feeling.

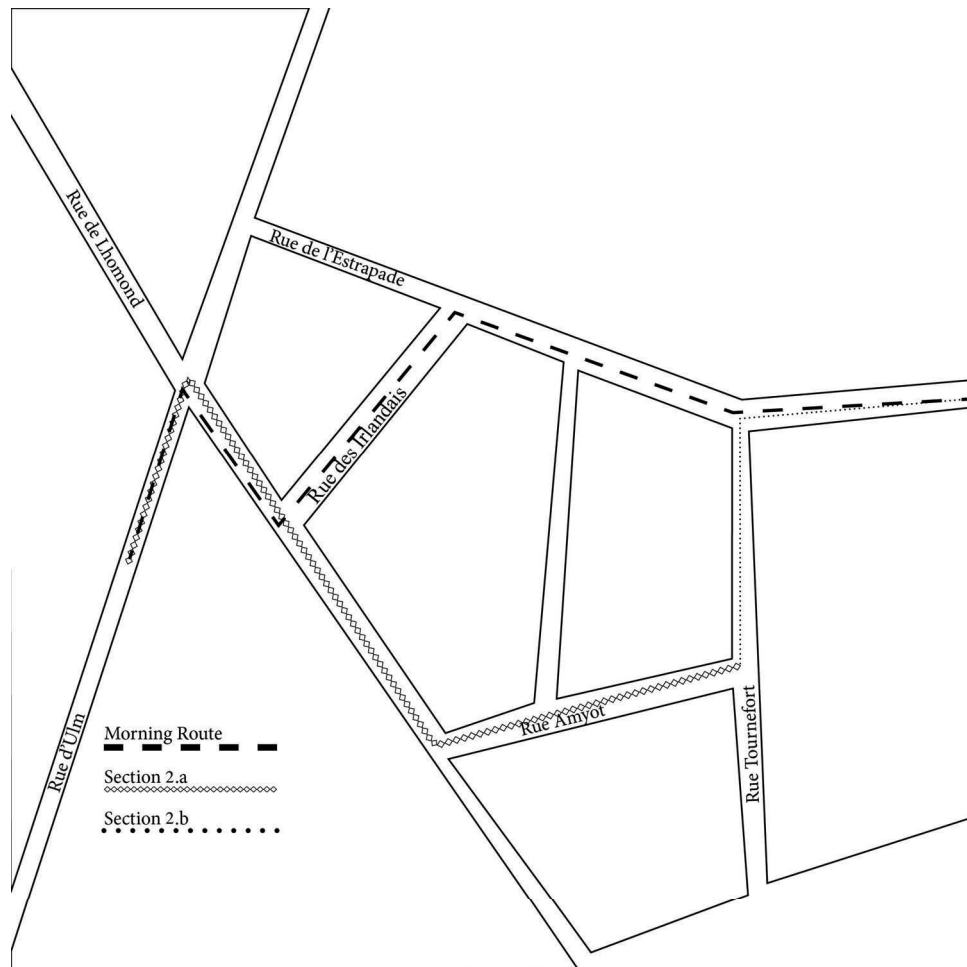
Scenario number 2 contains an example of the former, and scenario number 3 of the latter.

Scenario 2. Illusory feeling of orientation. “To go to work (29 rue d’Ulm), I come from Rue de l’Estrapade and then through Rue des Irlandais. It is not possible to cycle Rue des Irlandais on the opposite sense, so in the evenings I usually take Rue Amyot [which seems parallel to Rue des Irlandais]. When I started working and I first took Rue d’Amyot on the way back, I felt confused to find myself not in Rue de l’Estrapade, but in Rue Tournefort.”

To make sense of this scenario it is convenient to sub-divide the return path into two sections. Section 2.a extends from rue d’Ulm to Rue Amyot and the length of Rue Amyot before turning into Rue Tournefort, and section 2.b is that of Rue Tournefort (i.e. when the lost person realizes not being in Rue de l’Estrapade and onwards).

Using our characterization of subjective disorientation, the subject feels disoriented only in section 2.b, when she realizes that she is not in Rue de l’Estrapade. In contrast, if we use a third-person characterization (e.g. deviation from the most direct route), the subject is lost all along the return path, because she is taking a path (rue Amyot) that does not lead to Rue de

¹Daniel Montello makes a similar differentiation between being disoriented (subjective) and being misoriented (objective) (Montello, 2017). The main difference is that Montello characterizes subjective disorientation as a belief state and we cast subjective disorientation as an affective state, as will become clear in our next section.



l'Estrapade, where she wants to go. In other words, the subject is unable to find her way to Rue de l'Estrapade and all of her navigation is a manifestation of this inability. Section 2.b (just like scenario 1) is a case of disorientation for both the third-person and the subjective characterizations. In contrast, there is a misalignment in section 2.a between the two characterizations.

Another example of an illusory feeling of orientation is the phenomenon of veering. Souman and colleagues asked subjects to keep a straight path over several hours in a German forest unfamiliar to them (Souman, Frissen, Sreenivasa & Ernst, 2009). The subjects walking in good weather managed to keep a fairly straight course, but the subjects walking in cloudy conditions started to veer and ended up walking in circles, a common occurrence in lost person behavior (Hill, 1998). Of course, part of the problem is that subjects might be under the illusion that they are keeping a straight path when in fact they are veering.

Something that should be noted right away is that the feeling of disorientation is not functionally idle. It is the *effect* of an erroneous or insufficient representation of the environment, and it can *bring about* various psychological states and actions, such as anxiety or an urge to act or, conversely, inhibition or poor planning, depending on a variety of factors (Hill, 1998). The feeling in question, disorientation, is a key ingredient for understanding the deployment of further behavior. Moreover, feeling disoriented can be good for you, in particular if you *are* (objectively) lost. It may inhibit inappropriate behavior, or/and trigger reorientation practices. It may have costs if you are not objectively lost, but these costs are arguably lesser than the ones incurred in the case you are lost without feeling disoriented.

A good parallelism to understand the distinction we are after is provided by the distinction between danger and fear. Let us suppose that the formal object of fear is danger (Kenny, 1963). The function of fear is indicating (or registering, or representing) danger, but fear can occur erroneously, when its formal object, danger, is not actually present. John might be afraid while he is walking in the forest at night (because the trees seem to shift shapes or because of the eerie hoots of owls) even if objectively there is no danger. By contrast, if John is happily walking home in the middle of the day in a familiar street, and a mugger is following him to rob him, there is a real danger, but if John is completely unaware of it, he will not feel fear. Fear and danger may thus be not aligned. In the same way, according to our characterization, a subject can feel disoriented without actually being lost. The next scenario makes this vivid.

Scenario 3. Illusory feeling of disorientation. “I know my way from my home to my school [29 rue d’Ulm] and from my home to my work [Bastille] very well, but I have had difficulties every time that I have tried to go from rue d’Ulm to Bastille. Yesterday, I was going down rue Claude Bernard to Av. des Gobelins, and I perceived Boulevard Saint Michel as parallel to Claude Bernard [it is actually 135° oblique], which contradicted my mental map. This made me feel disoriented.

I ended up facing Rue du Fer à Moulin, which I vaguely remembered having followed once and that I believed had taken me to Jardin de Plantes. I decided to follow that. I was on the right way, but I still felt disoriented. I felt uncomfortable, I didn’t trust my own way-finding, and my mental map was incoherent. When I arrived to Rue Geoffroy Saint-Hillaire I found the path I take every day from my home to work. From then on, my sense of disorientation began to diminish.”

In scenario 3, the impression that Avenue des Gobelins is parallel to Boulevard Saint Michel contradicted the subject’s internal spatial representation, and disorientation ensued, even if the subject was eventually able to get to his destination (Pont d’Austerlitz), and even if he was following the shortest way throughout. Thus, according to the third-person view, this is *not* a case of a subject being lost, because she was finally able to find her way

to Pont d'Austerlitz. What makes this scenario (and illusory feelings of disorientation in general) so interesting is that although the subject is disoriented, she is still able to carry out the function of finding her way. The *illusory feeling of disorientation* leads the subject to erroneously assume that he is lost. This stands in contrast to the *illusory feeling of orientation*, in which the subject erroneously assumes that she is not lost (at the beginning of her route).

Of course, the aim of this section is not to completely separate the third-person and subjective aspects of being lost and disorientation. These two are generally concomitant, and are only temporarily apart in borderline cases. It is the subjective dimension that defines disorientation in our characterization, but if a subject is unable to find her way (as happens in scenario 2a) the likelihood of the subject experiencing disorientation increases (as is the case by the end of scenario 2b). The opposite is also true; if a subject is on the right way but disorientation occurs (as happens in scenario 3), the likelihood of the subject's disorientation waning and disappearing is very high (as is the case by the end of scenario 3).

6. The core claim: disorientation is a metacognitive feeling

If the subjective state of disorientation is not necessarily aligned with either a missing recognition of the place one is in nor with the objective condition of being lost, what does the state consist in?

The corpus of disorientation reports that we have collected can help us answer this question. The reports show that disorientation has an emotional dimension that should not be neglected. Subjects reported being

- *anxious* ("I didn't know where I was heading nor to which side of the station I was going. The feeling is horrible and stressful"; "I was anxious really anxious because I didn't want to be late to my first class"),
- *helpless* and *vulnerable* ("it made me feel vulnerable"; "I felt unsafe and anxious because no one was with me, and the environment was not familiar to me"; "I just felt confused and helpless – I didn't know what to do"),
- *confused* ("I was slightly confused, as all of the streets seemed similar and we kept walking in a circle although we took different turns")
- and *isolated* ("I get nervous the longer it takes me to figure out the direction. I attempt to find out which street/avenue I am at. It feels like I am a tiny spec in all this action that's happening around me"; "Feeling of being left alone, feeling of not being able to make decisions and unable to be independent.").

Another important affective element in many disorientation episodes is *unfamiliarity*. 66% of subjects agreed (from somewhat agree to strongly agree in a Likert scale) that the experience of disorientation made their surrounding environment feel unfamiliar.

Our claim is not that disorientation is always a highly arousing affective experience. There are instances in which disorientation occurs in a low stakes scenario and the agent remains calm throughout. Rather, the arousing instances of disorientation from the corpus help us identify some of the paradigmatic affective elements of the phenomenon. What is important about affective experience in general is that it involves (a) varying levels of valence and arousal and (b) a formal object. Phenomenal valence refers to the aspect of felt positivity (e.g. feeling happy) or negativity (e.g. feeling sad) (Charland, 2005; Colombetti, 2005) and felt arousal refers to the felt changes in levels of excitement, energy or activation (Colombetti & Harrison, 2018). Arousal can be low in some disorientation experiences, but in those cases, there is still a particular (negative) valence affectively permeating the experience. Moreover, as it will soon become clear, there is a formal object of the experience, a way that the experience assesses the situation.

As we mentioned in the previous section, another central aspect of disorientation is that it is functionally effective. Roughly speaking, disorientation results from shortcomings in the subject's orientation process and in turn it causes the subject to behave in a variety of ways in order to solve the said shortcomings – disorientation has an evaluative (and a regulative) function. Ideally, the subjective state of disorientation should track the objective state of being lost in order for the subject to stop being lost. The only way to make sense of this evaluative aspect of disorientation is to assume that disorientation is part of a process of metacognition that tracks the performance of orientation (i.e. of the online system of spatial representation mentioned in section 2).

The main question is how to square these two aspects of disorientation; the emotional aspect and the metacognitive aspect. Here, we can extend the notion of the formal objects of emotions to explain how emotions can be evaluative. Consider once more the relationship between fear and danger. If the formal object of fear is danger, then the affective state fear is evaluating whether or not a particular object (i.e. that to which the formal object is directed at, such as the bear one is afraid of) is dangerous. Furthermore, the fear causes the subject to act in a certain way (e.g. running away from the source of danger). A fundamental aspect of emotions is that they serve an evaluative-regulative function (Proust, 2013). The problem is that emotions such as fear seem to track properties that are quite far from disorientation (e.g. danger) and seem to track external objects (e.g. a bear) and not mental processes (e.g. the online system of spatial representation).

To be able to account for both the emotional aspect and the metacognitive aspect of disorientation, we need to depart from a conception of affective states as limited to basic emotions such as fear. A different subclass of affective states that has recently attracted a large research interest can help us do the necessary explanatory work: metacognitive feelings (see Arango-Muñoz & Michalean, 2014 for a review). Metacognitive feelings are described as phenomenal experiences concerning the subject's own mental states, processes or capacities. Some examples of metacognitive feelings are the feeling of knowing (Koriat, 2000), the tip-of-the-tongue state (Brown & McNeill, 1966), or the feeling of forgetting something (Arango-Muñoz, 2013).

A particularly important metacognitive feeling for the present discussion is the metacognitive feeling of confidence. When feeling disoriented, the subject does not have enough confidence in her capacity to find her way, in her estimations of cardinal directions, or she has very low confidence in her mental map of the space she happens to be in at a given moment. This low level of confidence is often linked with the other emotional aspects of disorientation such as vulnerability, confusion and anxiety. However, it is this low level of confidence that is at the heart of subjective disorientation. Highlighting the importance of the confidence factor narrows down the characterization of disorientation, but leaves open the following question: What is it that the subject has low confidence in? We characterize disorientation as a *metacognitive feeling of low confidence in the subject's online system of spatial representation*.²

What we understand by metacognition is the process through which a sub-system evaluates a particular aspect of cognition.³ In the case of disorientation, what is being evaluated by a metacognitive feeling is the level of confidence in the online system of spatial representation. The feeling of low confidence stands in contrast with the feeling of (high, complete) confidence (see Fleming & Dolan, 2012; Yeung & Summerfield, 2012 for reviews of the feeling of confidence). If a subject feels disoriented, this means that she has a low level of confidence on her online system of spatial representation. Confidence should be understood here as subpersonal-level confidence, not as personal-level confidence (see Dennett, 1969; Hornsby, 2000; Davies, 2000 for a discussion of subpersonal and personal levels in psychological explanation). Of course, the two conceptions of confidence tend to correlate, as we can see by subjects feeling unsure so often when disoriented. This is similar to the difference between personal-level surprise (e.g. the surprise a subject experiences in a surprise party) and subpersonal-level surprise (i.e. the surprise generated by stimuli that were unpredicted).

²The online system of spatial representation was introduced in section 2 in the context of the disorientation experiments of Waller and Hodgson (Waller & Hodgson, 2006).

³The notion of subsystem is clarified in section 7.

As we saw in section 2, the online system of spatial representation that is being tracked by the metacognitive feeling of disorientation is dynamic, transient and constantly updated, which means that the spatial representation in question is both *current* and *relevant*. In other words, the evaluation process is done in a context-sensitive way (Proust, 2015). The spatial representation that is being evaluated is *current* in the sense that it is the spatial representation of the space the subject is actually in at a given moment, and not the spatial representation of past or distant places (even when a subject feels disoriented about a remembered situation, the remembered situation is relived as if it were current). What we understand by *relevant* is that it is an action-oriented representation of a meaningful space. What the relevant space is is determined by the nature of the spatial task. Consider the following scenario:

Scenario 4. Relevance. I had just arrived at NYC and I did not have a map of the city. I needed to go to the 998 Columbus Avenue from midtown: I did so just by following the Columbus Avenue numbering without ever feeling disoriented.

In this case, the subject has a high enough confidence in his online system of spatial representation, because very little is needed for the spatial task. The necessary elements for his online system of spatial representation are his destination (north of Columbus Avenue), the path (998 Columbus Avenue) and his position (updated by checking the street numbers). Even without a good spatial representation of NYC, the subject can follow Columbus Avenue without feeling disoriented, because he can be confident in having these necessary elements of the spatial representation that is needed for the spatial task at hand. At the opposite end of the spectrum,

Scenario 5. 'Offline' spatial representation. I was in Manhattan last summer for a study-away course. One weekend heading out to hang out with my friends, I decided to take the metro. After arriving at my destination, I attempted to leave the subway station, which required me to take the stairs up to the surface level. I was still able to visualize a map of where I was, uptown and downtown Manhattan, East and West. However, once I was up the stairs and on the sidewalk, everything got louder, people walking in every direction, sounds of cars, people on their phones ... I tried desperately to find any sign of in which direction was what. I got very nervous. It felt like I was a tiny speck in all this action that was happening around me.

Here, the subject has a good offline spatial representation of Manhattan, but because she cannot use it in a relevant way in the space in which she finds herself after coming out of the metro, she feels disoriented. An online spatial representation is not an impersonal map of a remote city, no matter how well known, but is rather a meaningful representation of the space we are navigating, in which elements such as our destination, possible routes, landmarks, and cardinal directions are embedded. When the subject doesn't

have enough confidence in the system generating this online spatial representation, disorientation occurs.

7. Metacognition and affective states

When talking about metacognition as a cognitive subsystem evaluating a given aspect of cognition, there is a tendency to frame metacognition in *metarepresentational* terms, i.e. in terms of the second-order representation of first-order cognitive content. If this were the case, we would be forced to say that the low confidence that is characteristic of disorientation is a meta-representation, a representation of a spatial representation. Instead, we will follow Proust's claim that metacognitive feelings should be characterized in non-metarepresentational (and non-conceptual) terms (Proust, 2007). One can think, consciously, that one is wrong about her path, and even express this thought propositionally ("Mary convinced me that I was in the wrong meeting room"), but one can feel disoriented without thinking that she is and without being able to express it propositionally.

In her account, Proust claims that there are several properties (e.g. causal contiguity and epistemic transparency) that are present in metacognition but not in meta-representation. Discussing these properties is outside of the scope of this paper, but an additional argument for explaining metacognition in non-metarepresentational terms is that doing so is in line with the principle of parsimony: We should not postulate meta-representations if there is a way to explain metacognition without appealing to meta-representations. However, this begs the question of how metacognition works if not through meta-representation. A promising approach is an account of metacognitive feelings according to which somatic cues are ingredients of metacognitive feelings (for an example of this line of research see Koriat & Nussinson, 2009.) A recent experiment in this line of work demonstrated that metamemory beliefs (beliefs about the contents and accuracy of one's own memories) are positively correlated with interoceptive beliefs and that a subject's metamemory accuracy is positively correlated with interoceptive accuracy, which indicates that there is a common mechanism subserving both metacognition and interoception (Chua & Bliss-Moreau, 2016). Low confidence in the subject's current relevant spatial representation would elicit somatic cues that would in turn prompt the metacognitive feeling of disorientation.

Of course, it is likely that there are other factors outside somatic cues that contribute to metacognition. For example, in vision-related metacognition, several cues (e.g. evidence for a perceptual decision and visibility of the stimuli) are integrated to generate confidence (Rausch, Hellmann & Zehetleitner, 2018). At the computational level (Marr, 1982), research has successfully used a Bayesian framework to model the production of

metacognitive assessments (Fleming & Daw, 2017). The exact mechanisms and cues involved in generating the metacognitive feeling of disorientation remain an open empirical question, which lies outside the scope of this paper. The important thing for our argument is the plausibility of non-conceptual, non-metarepresentational metacognition, and support for this conception of metacognition might come from work on empirical or somatic cues or work on specific computational models.

The notion of subsystems is worth unpacking. Here, we understand subsystems in functional terms. The idea is that there are various subsystems that track the performance of different aspects of cognition, but at this stage we stay neutral on questions such as the somatic and neural underpinnings of said subsystems. A good example of a functional subsystem is the feeling of familiarity, as understood by the discrepancy-attribution hypothesis. According to Whittlesea and Williams' discrepancy-attribution hypothesis, the feeling of familiarity arises from the perception of a discrepancy between the actual and expected fluency of processing (Whittlesea & Williams, 1998). See below for an example.

"If one encounters the clerk from the corner store on a bus, dressed in civilian clothes, one may fail to identify the individual. In that case, one is likely to experience a feeling of familiarity. That feeling is due in part to fluent perception of the clerk's face but that fluency is no greater (probably less) than it was when the individual was met in the store. Instead, the feeling is produced by the discrepancy between fluent processing and a context in which all people should be strangers." (p. 560, Whittlesea & Williams, 2000).

Although not the only candidate for explaining familiarity, the discrepancy-attribution hypothesis has received substantial empirical support (Whittlesea & Williams, 2001a, 2001b), and it conceptualizes a metacognitive subsystem in functional terms, i.e. as a comparator of expected and actual fluency. In a similar vein, we characterize disorientation in functional terms, as a subsystem that monitors the performance of the online system of spatial representation.

There might be a relevant difference between the metacognitive feeling of disorientation and other metacognitive feelings such as the feeling of knowing (e.g. the feeling of knowing what the capital of Peru is even if one is unable to remember it at the moment). In the case of the feeling of knowing, the metacognitive feeling is a 'comment' on (i.e. it indicates something about) propositional knowledge. In the case of disorientation, the metacognitive feeling might sometimes be a 'comment' on an activity (i.e. the activity of orienting and wayfinding). The following scenario (although not a case of disorientation, but relevant for the general operation of wayfinding) is a case of a metacognitive feeling that is about an action, not about propositional knowledge:

Scenario 6. Feeling the wrongness of an action in space. "I started walking just outside Barbizon at the intersection of Allée de Vaches and chemin du Bornage. I noticed that the Chemin du Bornage was almost aligned with the sun. I moved a few hundred meters toward South East, then decided to head South, imagining to keep parallel to Bornage, walking in the woods after having left the path. This meant keeping the Sun a bit in front of me to my right. I noticed that once I had set for a heading, my body tried to keep that heading, no matter what. That is, if I intercepted a track winding right that took me back to Bornage, where I did *not* want to go, I felt an *urge* to go left that made me feel *uncomfortable* as long as I was on the track."

The subject in Scenario 6 reports a tendency to move in a direction that seems to be forced upon him. The subject has the feeling of not *doing the right thing*. It is a feeling that is associated to the action, not necessarily to a representation of the world; and it is a *feeling* about the action, not a representation of the action. The feeling in this case is caused by a form of wishful thinking. The subject in the above scenario reports he would like to be able to keep heading South (in the long run) and hopes that the path (that right now is heading West) in the long run will take him South. Feelings associated with actions instead of representations would not fall outside of metacognition; rather, they would be a subset of metacognition. If metacognition is not a meta-representation, but the result of a subsystem tracking another, then a source monitoring an action (such as keeping one's way) gives rise to a metacognitive feeling (e.g. not doing the right thing) of how one is doing the action. Such a feeling is not at the heart of disorientation, but in certain cases, the feeling of not doing the right thing leads to a metacognitive feeling of low confidence in the subject's online system of spatial representation, causing the subject to feel disoriented.

The question that arises with the case above is whether disorientation is really a metacognitive feeling indicating low confidence in an online system of spatial representation or in an action (i.e. orienting oneself). The main problem with saying that disorientation is a metacognitive feeling indicating low confidence in the action of orienting oneself is that this characterization is too restrictive, as it would leave outside many scenarios in which disorientation is not a feeling of *doing the wrong thing*, but of not knowing where one is. In contrast, characterizing disorientation in terms of the online system of spatial representation covers these scenarios.

Here again, we need to insist that the spatial representation that disorientation is associated with be current and relevant. It is relevant, and thus action-oriented, and it is current and thus continually updated as our actions unfold. The spatial representation at hand is a representation *in the world* and *of the world* and therefore, action and representation are highly entangled. Characterizing disorientation as a metacognitive feeling associated with an online system of spatial representation captures the importance of

actions such as orienting, because the spatial representation is a representation for action and is updated by action.

8. Exploring the factors and effects of disorientation

We mentioned above that disorientation feelings, like many other feelings, are not causally and functionally idle. They are not just concomitant factors of cognitive states that monitor one's location in the environment. Thus, they must have causes and produce consequences. It stands to evolutionary reason that the feeling of disorientation is entangled in a functional web. It is arguably useful to feel disoriented if indeed you are lost, and if it is useful, it is because feeling disoriented can induce a change in behavior that is hopefully conducive to finding one's way. Causal determinants of the disorientation feeling can coincide with those that induce the subject to get lost objectively or can include other elements. In the first case we call them *straightforward causal determinants*. If the light is switched off and you are made to spin, you are likely both to be objectively lost and to feel disoriented. The causal determinants of the feeling of disorientation are here straightforward as they are causal determinants of being lost as well. However, for those cases in which objective being lost and the feeling of disorientation are doubly misaligned, there might be a difference in their respective causes.

For instance, in the case explored in scenario 3, *Illusory feeling of disorientation*, in which the subject erroneously believes to have taken the wrong way when cycling from school to work, there are no elements causing the subject to be lost, but an error in perception (i.e. perceiving oblique streets as parallel) causes the subject to feel disoriented. There is a higher level of complexity in scenario 2, *Illusory feeling of orientation*. Here, the subject is objectively lost, but doesn't feel disoriented at first. It is only when she ends up in Rue Tournefort instead of in Rue de l'Estrapade that she becomes disoriented. What causes both being lost and subjective disorientation is that the subject had believed that there were four streets forming a square when in fact there were five streets forming a pentagon. What is interesting is that this error causes the subject to be lost right away, while subjective disorientation only arises when the subject arrives to an unexpected street. This shows how tightly linked being lost and feeling disoriented are even in cases of dissociation. The reason is that one of the main roles of the metacognitive feeling of disorientation is to track objectively being lost, so the causes of objectively being lost have a high likelihood of also causing subjective disorientation, even if the inverse might not be the case (as we saw in the example of scenario 3).

There are many elements that can play a casual role in the feeling of disorientation. One such element is lack of access to cardinal directions, as seen in scenario 5, *'Offline' spatial representation*, in which the subject felt

disoriented after coming out of the metro in NYC. Other possible elements are erroneous beliefs (e.g. scenario 7 below, in which the incorrect but tenacious belief that the sea is to the South causes the subject to become disoriented), the absence of a mental map (e.g. scenario 8 below, where the subject arrives to a new city and is unable to interpret the metro map) or the presence of visual impairments (e.g. scenario 9 below, in which the subject is Scuba diving and loses all sense of orientation due to darkness):

Scenario 7. Erroneous belief. Went the wrong way in Malmö, Sweden, due to an irrational belief that the water is to the South when it is in fact to the North. This happened several times.

Scenario 8. Novelty. I found the experience of the Tokyo Subway System very disorienting. I was totally lost. The signs were in a different language and maps were unintelligible.

Scenario 9. Visual Impairments. I was scuba diving in Croatia when we started entering deeper water and it got darker and darker. We then moved under a cliff which made it look as if everything was upside down, leading to many divers making mistakes equalizing their buoyance by inflating the jacket and thus actually moving closer to the cliff. I was not able to rely on my senses and it felt as if I was in a game or a different world of some sort.

Another very interesting, if easily overlooked element, is place recognition (or its absence). The absence of place recognition can elicit disorientation, but interestingly, unexpected place recognition can do so as well. We will look at two real-life scenarios to help us understand the role that place recognition plays in disorientation:

Scenario 10. Place recognition induces the disorientation feeling. “In 1990 I first visited Berlin, immediately after the Wall came down. Boundary checks were still enacted. There were only a few passages from West to East. I went through the checks at Checkpoint Charlie, followed a tortuous path, made a turn, saw an “Ausgang” (“Exit”) sign, and exited the Checkpoint – only to find myself once more in the West! The realization that I was back to the starting point was initially of disorientation.”

The setting is one of stress and pressure: the person was going for the first time to a country of the former Eastern Europe, in a politically and historically charged context, paid attention to many aspects of the situation (armed soldiers, perceived as threatening) and did not monitor spatial progress or updated his position in an effective way. It is important to note that the disorientation feeling first occurred *when he realized that he was back at the starting point*. Then, he *knew* where he was, but he felt disoriented (in fact, it is *because* of this knowledge that the feeling of disorientation set in.) The disorientation feeling seems to serve here in the monitoring of recent spatial activity, retrospectively (e.g. “I was wrong in my beliefs about my whereabouts” or “I realized that I was in the wrong place, relative to my

expectations”). Thus recognition has the power to induce a disorientation feeling. This becomes even clearer in the following case:

Scenario 11. Fog disorientation: recognition induces disorientation feeling. “Coming back from Barbizon, on the Bornage trail near the Maison Forestiere de Macherin. 10am, fog, visibility 40 m. I exit the Bornage trail heading toward home, at a precise point we marked with a stone. I know there is no trail and I try to pass a first series of hedges. I keep a bit on the left assuming I will get close to the series of fenced properties one of which is mine. NB I probably came in this area 50 times before. At some point I cross a totally unexpected large trail. I am surprised. I think I am still oriented, heading in the right direction, hence I try to locate that unexpected trail on my mental map. I think: Perhaps it is a new path created by the Bost farmers to collect logs. But all of a sudden, I recognize that it is the Bornage trail: I went full circle, coming back almost to starting point. Now I feel disoriented, and have to reset the mental map.”

In this scenario, the subject does not feel disoriented at first, even if he is objectively lost. For that reason, when he encounters a trail that he thought he had left behind, he does not recognize it. He did not expect the trail, so he perceives it as a new trail that she did not know exist. Only after the recognition of the trail does the feeling of disorientation arise, followed by a resetting of the subject’s mental map.

The “dual” theory of reasoning might help us understand the above scenario and the functional role of the disorientation feeling. According to this framework, there are two modes (also referred to as systems in some of the literature) of operation during decision-making tasks (Evans, 2003, 2012, 2015 for reviews; Evans & Frankish, 2009; Kahneman, 2011). “Mode 1 (M1, for brevity) is an automatic, autonomous, stimulus-driven, fast operating mode that delivers rough but locally acceptable results; M2 [Mode 2] is modulated by will and attention, operates slowly and stepwise, intensely uses working memory, and is in general more accurate” (Casati, 2017). A candidate functional role of the disorientation feeling, as with many other cognitive feelings, is to block a type-1 mode of functioning (M1), and to activate a type-2 mode of functioning (M2).⁴ The metacognitive feeling of disorientation can shift us from M1 to M2: metacognitive feelings signal that M1 is not functioning, block action, set thought in motion. The person who feels disoriented may stop relying on her intuition about directions and start deploying reflective means of wayfinding (think about the path traveled, look for known landmarks, ask for directions.) Relatedly, disorientation might inhibit the use of the online system of spatial representation and facilitate the use of the offline system of spatial representation, in line with Waller and Hodgson’s finding that disorientation decreases target pointing accuracy, but increases inter-object pointing accuracy (i.e. judging the relative directions

⁴However, it should be noted that in disorientation episodes of high stress, the subject might be locked in Mode 1, as stress is “a state in which an individual is unable to instigate a clear pattern of behavior to remove or alter the event (...) that is threatening an existing goal” (pp. 206–207, Power & Dalgleish, 1997).

between different objects in the room, such as “Imagine that you are at the door, facing the TV. Point to the fabric”), which relies on the offline system of spatial representation (see Allen and Haun, 2004 for a discussion of dual theories of spatial memory).

Before concluding, we would like to mention another relevant factor. Namely, the *metacognitive feeling propagation* that disorientation can induce: you are disoriented, and this in turn causes you to have a feeling of uncertainty as well. Interestingly, there could even be propagation at the affective level, without changes in the cognitive representations or tasks that the metacognitive feelings are monitoring. For instance, if you have a misfeeling of disorientation (e.g. you suspect you are too close to the marsh, when in reality you aren't), this could make you feel uncertain about the next steps on the ground, where actually you have no reason to feel so (you are on solid ground), which might in turn propagate to a metacognitive feeling of error (the feeling that there is something wrong with your walking) or even feedback on the feeling of disorientation.

9. Conclusion and further directions

In the opening sections of this paper we argued that an adequate characterization of disorientation was essential to link the broad-ranging literature on disorientation into a unified conceptualization of the phenomenon. Our strategy was to study different scenarios of human disorientation that would constrain its characterization. We showed a misalignment between objective and subjective characterizations (of being lost and of feeling disoriented, respectively). The aim was not to separate being lost and feeling disoriented unreservedly, but to argue that disorientation can be fully characterized subjectively and that the third-personal aspect of being lost is a critical dimension of the phenomenon. We then characterized spatial disorientation as the metacognitive feeling that occurs when the subject has a critical low-level confidence in her online system of spatial representation. In the final section of this paper, we provided a link between the causes of disorientation, the subjective experience of disorientation, and the resulting behavior.

A clear future direction in this line of work is to put the conceptual work developed here to empirical test. The idea is not only to test whether or not disorientation is a metacognitive feeling, but also to further our understanding of the particular mechanisms underlying said metacognitive feeling. An advantage here is that there is already a good working knowledge of how metacognitive feelings work, and we can benefit from this research to further our understanding of how disorientation emerges and how it influences behavior.

In the future, this new characterization of disorientation can be used to link distant fields related to the phenomenon. It would be important, for


example, to provide a good functional and neural framework for the meta-cognitive feeling of disorientation and to see how it relates to other elements in the research on spatial cognition such as the study of the neural underpinnings of disorientation (Dudchenko, 2010; Wiener & Taube, 2005). Advancing on this line will allow us to have a better ground to predict and explain the behavior of disoriented subjects, and to understand how different environments and situations can induce disorientation. Eventually, it is our hope that this knowledge can be used to prevent and remediate disorientation.

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Appendix Scenario Table

Scenario	Title
1	Paradigmatic Disorientation Case
2	Illusory feeling of orientation
3	Illusory feeling of disorientation
4	Relevance
5	'Offline' spatial representation
6	Feeling the wrongness of an action in space
7	Erroneous belief
8	Novelty
9	Visual Impairments
10	Place recognition
11	Fog disorientation: recognition induces disorientation feeling