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Michel Aurnague, Maud Champagne, Laure Vieu, Andrée Borillo, Philippe Muller, et al.. Categorizing spatial entities with frontal orientation: the role of function, motion and saliency in the processing of the French Internal Localization Nouns 'avant/devant'. Michel Aurnague; Maya Hickmann; Laure Vieu. The categorization of spatial entities in language and cognition, 20, John Benjamins Publishing Company, pp.153-175, 2007, Human Cognitive Processing, 978 90 272 2374 6. <10.1075/hcp.20.10aur>. <hal-01078681>

HAL Id: hal-01078681

<https://hal.archives-ouvertes.fr/hal-01078681>

Submitted on 29 Oct 2014

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**Categorizing Spatial Entities with Frontal Orientation:
the Role of Function, Motion and Saliency in the Processing of the
French Internal Localization Nouns *avant/devant***

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1. Introduction¹

For years, linguists and psycholinguists have studied in depth the different kinds of “orientation strategies” that may be involved in language use (Hill, 1982; Kleiber, 1988; Klein, 1983; Levinson, 1996; Miller & Johnson-Laird, 1976; Vandeloise, 1986). Consider a few illustrations of some of these observed patterns. When the orientation that is associated with an entity directly derives from the “internal” properties of this entity, an “intrinsic”/“object-centered” orientation is at work. If the orientation depends on factors that are not related to the entity itself, the orientation is called “contextual”. An important subgroup of contextual orientations comprises situations in which the speaker/viewer applies his/her own (intrinsic) orientation to the entity being oriented (“deictic”/“viewer-centered” orientation). The following examples involving the French preposition *devant* (‘in front of’) illustrate these three cases:

(1) *La poubelle est devant la maison.*

‘The trash-can is in front of the house.’

(2) *La poubelle est devant l’arbre au/du coin de la cour.*

‘The trash-can is in front of the tree at/in the corner of the yard.’

(3) *Regarde cette poubelle devant l’arbre !*

‘Look at this trash-can in front of the tree!’

Whereas the reference entity or landmark (the house) in sentence (1) determines an intrinsic frontal orientation (because a house usually has a façade), the landmark in (2) is contextually oriented, the front of the tree

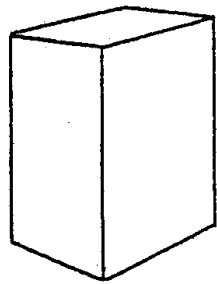
being the side facing the center of the yard (contextual front and back). Finally, in (3) it is the speaker who makes use of his/her own frontal orientation to give a deictic front to the entity (in a “mirror” fashion).²

As the above comments suggest, interpreting orientational prepositions imply being able to associate a part of the reference entity or landmark with a suitable orientation. As a result, it is not surprising to find several nouns pointing to the oriented parts of spatial entities in many languages (e.g., *avant* (‘front’), *derrière* (‘back surface’), *bas* (‘bottom’), *gauche* (‘left’), *côté* (‘side’)). These markers belong to a bigger class of nouns (hereafter Internal Localization Nouns or ILNs) which designate parts of spatial entities on the basis of various properties, that may be orientational (see the examples above), topological (e.g., *intérieur* (‘interior’), *bord* (‘edge’)) or distance-related (e.g., *extrémité* (‘extremity’), *centre/milieu* (‘centre/middle’)) (Aurnague, 1996, 2004; Borillo, 1988, 1999).

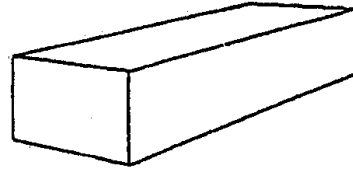
Although the different ways of processing orientation in language have been widely studied (see above), the factors that make the emergence of each kind of orientation possible, as well as those that condition the choices between different potential strategies, have not been fully described (Carlson-Radvansky & Irwin, 1993; Schober, 1993; Tversky, 1996). This paper attempts to contribute to this issue by focusing on the French ILNs *avant* (‘front’)/*devant* (‘front surface’), whose intrinsic and deictic interpretations are analyzed in depth (contextual interpretations other than deictic ones are left aside). As will be shown, four factors, that have not

been much discussed in the literature (Vandeloise, 1986), underlie the emergence of intrinsic or deictic frontal orientations when processing the ILNs *avant* and *devant*. The first two factors concern the internal/intrinsic properties of spatial entities which are related to their function. These functional properties may have to do with the static use of entities by human beings (e.g., selecting the side we interact with when opening a cupboard, when watching television, etc.) which is often reflected in the shape and the internal arrangement of the parts (“static function”). In other cases, they are more clearly related to the canonical way in which dynamic entities move (“dynamic function”) —a feature that is also exhibited by their internal structure—, whether this motion is autonomous (e.g., animate) or guided/caused (e.g., car, bicycle). The third and fourth factors are not strictly internal or intrinsic and partly rely on contextual parameters which combine with geometrical (internal) properties. The “aerodynamicity” of shape characterizes the fact that elongated entities, presented horizontally, evoke motion. When the largest dimension of the entity is localized on the horizontal plane (as with a parallelepiped lying down), one of the ends along this axis (e.g., one of the small sides of a parallelepiped lying down) is selected as the front, as if it were ahead in a possible motion. Finally, the “saliency” of a side may induce its selection as the front, depending on its orientation with respect to the viewer and more precisely on the relative size of its visible area and the degree to which it faces him/her (angle of presentation).

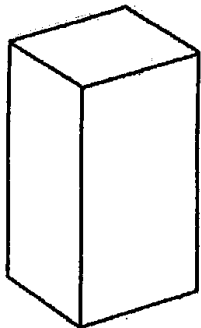
We examined the role of these factors in a psycholinguistic experiment on orientational ILNs (in addition to *avant* and *devant*, other markers were also analyzed such as *haut* ('top'), *bas* ('bottom'), *gauche* ('left'), *droite* ('right'), *côté* ('side'), etc.). Fifty French-speaking subjects participated in the experiment (mean age: 21 years, 8 males, 42 females, all students or staff members of the "Université de Toulouse-Le Mirail"). The processing of frontal orientation was assessed for the ILNs *avant* and *devant* applied either to purely geometrical shapes (e.g., parallelepiped standing up #2 (Figure 1c), parallelepiped lying down #2 (Figure 1d), cube (Figure 1e)) or to functional entities (e.g., parallelepipedic houses with a right/left façade (Figure 2b/c), square houses with a right/left façade (Figure 2d/e), standard and open-sided vans (Figure 3a/b)).



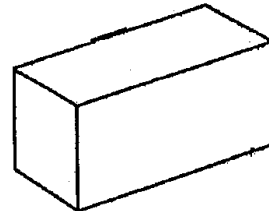
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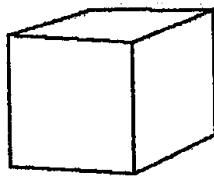
b



c



d



e

Figure 1: a. Paral. standing up #1, b. Paral. lying down #1, c. Paral. standing up #2, d. Paral. lying down #2, e: Cube

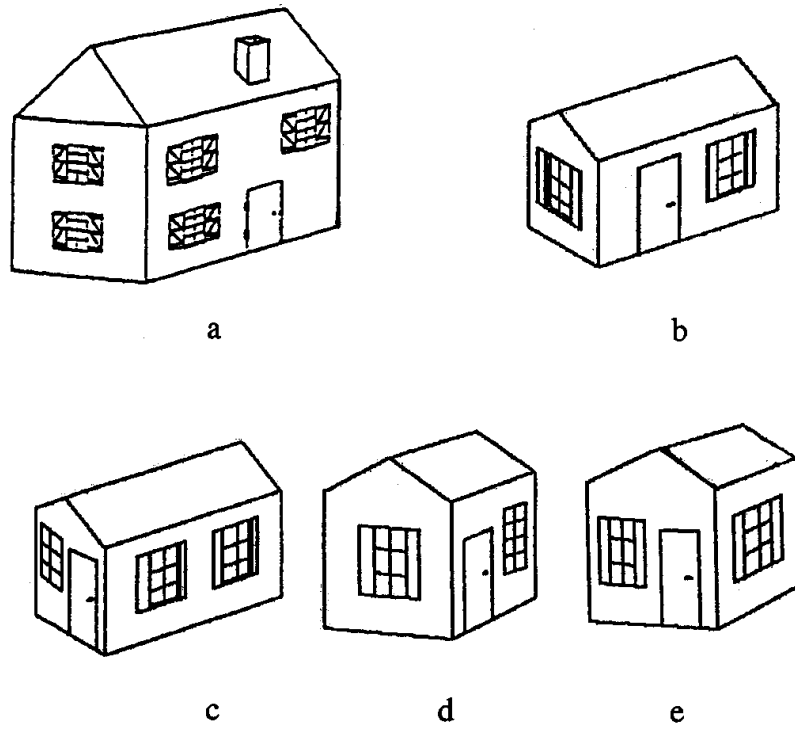


Figure 2: a. Paral. house right faç. #1, b. Paral. house right faç. #2, c. Paral. house left faç., d. Square house right faç., e. Square house left faç.

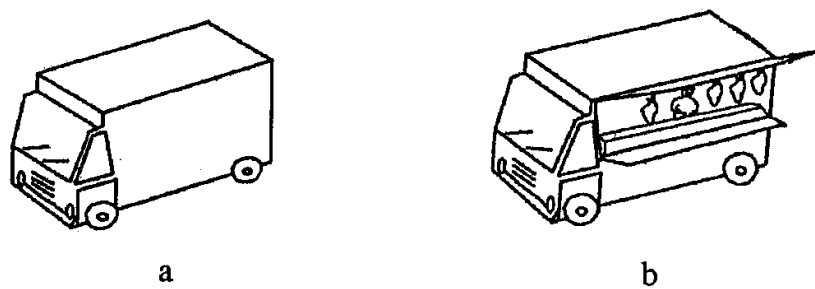


Figure 3: a. Standard van, b. Open-sided van

The experiment consisted of a pointing task.³ The subjects were facing a tactile computer screen which displayed a series of stimuli, each consisting of a spatial entity (black-and-white drawing) and an ILN. These stimuli (entity + ILN) were presented in a random order, each only once. With each stimulus the subjects were asked (a) to point as quickly as possible —from a fixed spot on the table (located 25cm from the bottom of the screen)— to the part of the entity corresponding to the word and (b) to put their finger back on the spot immediately afterwards. The next stimulus automatically appeared two seconds after the hit.

The x/y positions of the hits were recorded, as well as the latencies between the presentation of the stimulus and the moment when the finger hit the screen. Since the latencies included different underlying processes (visual information intake + decision + finger moving time), immediately after the first part of the experiment (described above) the subjects were presented with 1 cm square targets which appeared on the screen precisely where the finger hits had taken place (in the first part). Again, they were asked to point as quickly as possible to these targets. This elementary pointing task allowed us to subtract the moving time from the overall latency (latencies in Tables 1, 2 and 3 take into account this subtraction). In order to ensure that the subjects had correctly understood what they had to do in the two parts of the experiment, a set of five stimuli was presented for each subset before the beginning of the experiment proper.⁴

After isolating and ordering the factors which underlie the frontal orientations involved in the interpretation of *avant* and *devant* (section 2), we show below that the semantic content of an ILN can sometimes strengthen the role of a given factor or property (section 3). We then mention the results of an additional judgment task which provide complementary information about the processing of *avant* and *devant* (section 4). Finally, we consider some outcomes of this research for the classification of spatial entities in language and cognition (section 5).

2. Isolating and ordering the factors

2.1. Isolating the factors

We first examine the distribution of responses obtained in the pointing task in order to isolate the factors which underlie the frontal orientation involved in the semantics of *avant* and *devant*. It should be noted that for each stimulus (entity-ILN pair) the recorded x/y positions of the hits were grouped together according to the sides or faces they identified. The division into zones resulting from these groupings allowed us to distinguish the different interpretations that were made for the concerned ILN-entity pair.⁵

The best way to show that a given factor affects subjects' strategies is to compare a ("neutral") situation in which none of the four factors studied are

present with a configuration that only differs from it by virtue of this factor (0 factor/1 factor). For example, this is the case of the parallelepiped standing up #1 (Figure 1a; no aerodynamicity, two equally salient (vertical) sides, no function (geometrical entity)) as compared to the parallelepiped standing up #2 (Figure 1c; no aerodynamicity, no function, but saliency) whose right vertical side is more “salient” than its left side because of the angle of presentation of these two elements.⁶ If a particular factor is effective, its introduction has to modify the distribution in a significant way, since the interpretation that involves this factor should “attract” most of the hits.

However, it is not always easy to find configurations that avoid all the factors studied (neutral configurations) and that can therefore serve as reference points for the comparisons. In particular, this is true for functional properties and configurations. For instance, the “standard” van in Figure 3a is geometrically similar to the parallelepiped lying down #2 in Figure 1d — and only differs from it by the presence of a “dynamic function”—, but the latter already involves aerodynamicity (in other words, dynamic function very often co-occurs with aerodynamicity). In such cases, even if it is not entirely neutral, the configuration that lacks the factor analyzed (e.g., the dynamic function in the parallelepiped lying down) will be taken as reference point and compared with the entity presenting this factor (e.g., van; n factors/n + 1 factors). Here again, the presence of the factor should modify the distribution of responses in a significant way.

2.1.1. Aerodynamicity

We can show the role of aerodynamicity by comparing the parallelepiped standing up #1 (Figure 1a), which does not involve any of the four factors studied (neutral configuration), with the equivalent entity lying down (parallelepiped lying down #1: Figure 1b), which only involves aerodynamicity. The aerodynamic nature of the parallelepiped lying down results from the positioning of its largest dimension on the horizontal plane.⁷ In the case of the parallelepiped standing up #1, the interpretations of the ILN *avant* (*devant* was not tested) were relatively well-balanced between the right and left sides facing the subjects (Table 1; RF: 23, LF: 19, EL: 5).⁸ When the parallelepiped was displayed lying down, this pattern no longer existed and most subjects chose the left side —located at the end of the “aerodynamic” dimension very close to them (Table 1; RF: 8, LF: 32, EL: 7). These two distributions (parallelepiped standing up #1, parallelepiped lying down #1) were significantly different ($\chi^2(1)=10.52$, $p<.0012$), attesting the role of aerodynamicity in the processing of frontal orientation. No other comparison with a neutral configuration was available for aerodynamicity.

Table 1. Geometrical entities (pointing task)

Entity	RF [†]		LF		EL
	N	RL (ms)	N	RL (ms)	N
Paral. standing up #1 <i>avant</i>	23	1004	19	901	5
Paral. lying down #1 <i>avant</i>	8	815	32	768	7
Paral. standing up #2 <i>avant</i>	35	645	3	827	12
Paral. standing up #2 <i>devant</i>	41	613	3	656	6
Paral. lying down #2 <i>avant</i>	19	902	26	698	5
Paral. lying down #2 <i>devant</i>	22	675	23	681	5
Cube <i>avant</i>	2	532	44	670	4
Cube <i>devant</i>	5	673	44	570	1

[†] RF: right front, LF: left front, EL: eliminated, N: number of responses, RL: response latency.

2.1.2. Geometrical saliency

We can show the role of saliency by examining the distributions obtained for a cube (Figure 1e) whose left side is more salient than its right side because of the way these two parts are presented to the subjects (factors other than saliency are missing).⁹ Although, in this example, the angle of presentation is the only variable which determines saliency, note that in some cases the visible surface area of the parts/sides can operate as an additional parameter (here the two appearing areas are practically equivalent).

A large majority of subjects pointed to the salient side of the cube (left side) for both *avant* and *devant* (Table 1; *avant* RF: 2, LF: 44, EL: 4; *devant* RF: 5, LF: 44, EL: 1) and these two distributions appeared as significantly different from a random choice (*avant* $\chi^2(1)=24.22$, $p<.0001$; *devant*: $\chi^2(1)=18.55$, $p<.0001$). Therefore, saliency seems to be responsible for these results.

The role of this parameter also appears when we compare the parallelepiped standing up #1 (Figure 1a; neutral configuration) and the parallelepiped standing up #2 (Figure 1c): as noted above, the latter mainly differs from the former by virtue of the angle of presentation of the two sides (saliency: the right side is more salient than the left one). Whereas the distributions recorded for the parallelepiped #2 showed a marked preference for the right (salient) side (Table 1; *avant* RF: 35, LF: 3, EL: 12; *devant* RF: 41, LF: 3, EL: 6), a comparison with the parallelepiped #1 (for *avant*) indicated that the corresponding distributions were significantly different ($\chi^2(1)=13.95$, $p<.0002$). The introduction of saliency has, here again, a direct effect on the processing of frontal orientation.

These configurations (cube, parallelepiped standing up #1 and #2) were the only neutral and/or “salient” situations (saliency alone) in the experiment.

2.1.3. *Static function*

The analysis of functional factors is also based on two by two comparisons although, for the reasons previously given, it is usually not possible to take a neutral configuration as a reference point.

We can test the role of static function by comparing the parallelepiped lying down #2 (Figure 1d) with the second parallelepipedic house whose façade coincides with the right side (Figure 2b). These two entities, as they are presented to the subject, are geometrically similar (aerodynamicity (left side), saliency (right side)) and their only difference lies in the (static)

functional properties entailed by the presence of the main entrance, i.e., the “front” door and the façade (the function of “letting in”). Whereas the distributions obtained for the parallelepiped lying down #2 were quite well balanced, a result which is due to the opposite role of aerodynamicity and saliency (Table 1; *avant* RF: 19, LF: 26, EL: 5; *devant* RF: 22, LF: 23, EL: 5), the introduction of a static function (façade of the house) drastically changed this equilibrium by attracting most of the hits to the right side of the house —intrinsic interpretation— (Table 2; *avant* IT: 38, DT: 7, EL: 5; *devant* IT: 42, DT: 5, EL: 3). These differences between the distributions (parallelepiped lying down #2 and parallelepipedic house right façade #2) were statistically significant (*avant* $\chi^2(1)=17.3$, $p<.0001$; *devant*: $\chi^2(1)=17.8$, $p<.0001$).

We also compared the parallelepiped lying down #2 with the parallelepipedic house “left façade” (Figure 2c), on the one hand, and the cube (Figure 1e) with the square house “right façade” (Figure 2d), on the other hand. The results of these comparisons were similar to the above mentioned ones and confirmed the influence of the static function on the interpretation of *avant* and *devant*.

Table 2. Houses (pointing task)

Entity	IT [†]		DT		EL
	N	RL (ms)	N	RL (ms)	N
Paral. house right faç. #1 <i>avant</i>	34	1043	13	764	0
Paral. house right faç. #1 <i>devant</i>	36	852	10	640	1
Paral. house right faç. #2 <i>avant</i>	38	746	7	1069	5
Paral. house right faç. #2 <i>devant</i>	42	684	5	511	3
Paral. house left faç. <i>avant</i>	45	664	3	766	2
Paral. house left faç. <i>devant</i>	42	620	6	721	2
Square house right faç. <i>avant</i>	30	629	17	844	3
Square house right faç. <i>devant</i>	36	760	10	738	4
Square house left faç. <i>avant</i>	46	662	0	0	4
Square house left faç. <i>devant</i>	46	645	0	0	4

[†] IT: intrinsic, DT: deictic, EL: eliminated, N: number of responses, RL: response latency.

2.1.4. Dynamic function

Finally, we can show the role of the last factor in this experiment, dynamic function, by comparing the parallelepiped lying down #2 (Figure 1d) with a “standard” van (Figure 3a). Here again, these two entities are geometrically similar (aerodynamicity (left side), saliency (right side)). The only difference between them lies in the fact that the van is “dynamic” or mobile (detected in the very recognition of the entity, that is in the internal arrangement of its parts), which gives a particular predominance to the left side as a front. Indeed, the relative balance observed for the parallelepiped lying down #2 (Table 1; *avant* RF: 19, LF: 26, EL: 5; *devant* RF: 22, LF: 23, EL: 5) was not preserved for the van, whose distribution revealed a marked tendency for the subjects to choose the left side —i.e., the intrinsic interpretation— (Table 3; *avant* IT: 37, DT: 3, EL: 10; *devant* IT: 45, DT: 1, EL: 4). These changes, entailed by the introduction of a dynamic function, were significant (*avant* $\chi^2(1)=13.3, p<.0003$; *devant* $\chi^2(1)=28.1, p<.0001$).

The experiment provided no other possibility to compare a mobile entity and an equivalent geometrical entity, that is two configurations that only differed by virtue of a dynamic function.

Table 3. Vans (pointing task)

Entity	IT [†]		DT-IL		EL
	N	RL (ms)	N	RL (ms)	N
Standard van <i>avant</i>	37	591	3	1189	10
Standard van <i>devant</i>	45	589	1	576	4
Open-sided van <i>avant</i>	37	682	6	953	7
Open-sided van <i>devant</i>	32	596	14	755	3

[†] IT: intrinsic, DT: deictic, IL: intrinsic lateral (right side), EL: eliminated, N: number of responses, RL: response latency.

2.2. Ordering the factors

Having identified the factors that govern frontal orientation in subjects' interpretations of the ILNs *avant* and *devant*, we now assess their respective “weights” in the process. Ordering two factors consists in observing the stimuli in which they are both present and yield different “fronts”, in the absence of other parameters. If the interpretation of an ILN that calls for a given factor A is systematically and significantly more frequent than the interpretation calling for another factor B, then factor A can be considered to be stronger than the competing parameter. However, it is not always easy to find situations where only a given pair of factors is present: for instance, as noted above, dynamic function generally coincides with aerodynamicity, and comparisons involving the former also entail the presence of the latter. Of course, such cases will be pointed out.

In the following sections (2.2.1 and 2.2.2), we successively compare static and dynamic functions with aerodynamicity and saliency (geometric-contextual factors). The results of the experiment show that these geometrical parameters are not totally ordered (section 2.2.3). The comparison between static and dynamic functions will be discussed subsequently (section 3).

2.2.1. *Static function and geometrical factors*

Static function > aerodynamicity. The relative weights of static function and of aerodynamicity are assessed by means of a house which is geometrically similar to the parallelepiped lying down #1 and whose façade is located on the right face (parallelepipedic house right façade #1; Figure 2a). Whereas a frontal orientation based on aerodynamicity is likely to favor the left side of the house (deictic front), a calculation involving the static function of the house (here revealed by the façade) will result in designating its right side (intrinsic front).¹⁰ The distributions obtained show that a larger number of subjects resorted to the static function (right side/intrinsic interpretation) than to aerodynamicity (left side/deictic orientation) when interpreting *avant* and *devant* (Table 2; *avant* IT: 34, DT: 13, EL: 0; *devant* IT: 36, DT: 10, EL: 1). These results were significantly different from a random choice (*avant* $\chi^2(1)=4.98$, $p<.0256$; *devant* ($\chi^2(1)=7.98$, $p<.0047$) and consequently static function can be considered to have a stronger effect on frontal orientation than aerodynamicity. The experiment included no other

stimulus in which static function was competing with aerodynamicity (other factors excluded).

Static function > saliency. The relations between static function and saliency can be examined with the square house in Figure 2d which has a salient left side and a façade located on the right side (static function). The distributions corresponding to *avant* and *devant* indicate that the side associated with the static function (right side/intrinsic interpretation) was chosen by more subjects than the salient side (left side/deictic interpretation) (Table 2; *avant* IT: 30, DT: 17, EL: 3; *devant* IT: 36, DT 10, EL: 4). These results were significant for *devant* ($\chi^2(1)=7.98, p<.0047$), but not for *avant* ($\chi^2(1)=1.85, p<.1736$). Although not entirely satisfactory, these data indicate a clear trend suggesting that static function outmatches saliency. This configuration was the only one where static function and saliency were opposed without the presence of additional factors.

2.2.2. *Dynamic function and geometrical factors*

Dynamic function > aerodynamicity. As noted above, entities intended to move very often fulfill aerodynamic constraints (in particular, their largest dimension is aligned with the usual direction of motion). As a consequence, dynamic function and aerodynamicity coincide most of the time. Indeed, there was no entity in the experiment which dissociated these two elements and the question of their relative weights could not be directly addressed.¹¹

However, a closer look at the data provides some indirect evidence. The dominance of the static function over aerodynamicity (cf. section 2.2.1) and the fact (which will be shown in section 3.2) that the dynamic function seems to outmatch the static function suggests that the dynamic function very probably has a stronger effect on the calculation of frontal orientation than aerodynamicity.

Dynamic function > saliency. The standard van previously examined (Figure 3a) presents a pattern in which dynamic function and saliency are opposed and competing parameters. While the internal arrangement of parts indicates that the left side is canonically orientated towards the direction of motion (dynamic function), the right side of the van is the most salient (angle of presentation). For both *avant* and *devant*, the distributions showed that a great majority of subjects chose a frontal orientation based on the dynamic function (left side/intrinsic interpretation) rather than on saliency (right side/deictic interpretation) (Table 3; *avant* IT: 37, DT: 3, EL: 10; *devant* IT: 45, DT: 1, EL: 4). These distributions were significantly different from a random choice (*avant* $\chi^2(1)=17.63$, $p<.0001$; *devant* $\chi^2(1)=27.28$, $p<.0001$), suggesting that dynamic function is a stronger factor than saliency.

Following our previous remarks, it could be argued that the standard van associates a dynamic function with aerodynamicity, so that our results show the superiority of both dynamic function and aerodynamicity on saliency.

However, the relations between dynamic function, static function, and saliency (dynamic function > static function (section 3.2), static function > saliency (section 2.2.1)) suggests that dynamic function is indeed a stronger factor than saliency.

No other stimulus was used in which dynamic function (with aerodynamicity) would be competing with saliency alone.

2.2.3. Geometrical factors: aerodynamicity and saliency

$\neg(\text{aerodynamicity} > \text{saliency})$ and $\neg(\text{saliency} > \text{aerodynamicity})$. The parallelepiped lying down #2 (Figure 1d) previously examined (section 2.1.3) displays a left “aerodynamic” side and a right “salient” side. As already pointed out, the processing of *avant* and *devant* by the subjects resulted in a well-balanced distribution between a frontal orientation based on aerodynamicity (left side) and a frontal orientation involving saliency (right side) (Table 1; *avant* RF: 19, LF: 26, EL: 5; *devant* RF: 22, LF: 23, EL: 5).¹² These distributions were not statistically different from a random choice (*avant* $\chi^2(1)=0.55$, $p<.4568$; *devant* $\chi^2(1)=0.11$, $p<.9156$). On the basis of these results, no predominance or priority of one factor over the other can be deduced.

Although the parallelepiped lying down #2 was the only configuration that exclusively involved aerodynamicity and saliency, other observations allowed us to strengthen our conclusion that these factors may not be ordered. In particular, it is revealing to examine the parallelepipedic house

with a right façade #2 (Figure 2b) and the parallelepipedic house whose façade occupies the left side (Figure 2c). The former has a right face associating saliency and static function, as well as a left “aerodynamic” face (parallelepipedic house right façade #2: saliency + static function versus aerodynamicity). The latter has a left face which combines aerodynamicity with static function, its right face being salient (parallelepipedic house left façade: aerodynamicity + static function versus saliency). If aerodynamicity and saliency had different relative “weights”, one would expect their combination with static function—together with their opposition to the competing factor—to give rise to different ways of calculating frontal orientation. However, the results recorded for the two parallelepipedic houses for both *avant* (Table 2; “right façade #2” IT/right: 38, DT/left: 7, EL: 5; “left façade” IT/left: 45, DT/right: 3, EL: 2) and *devant* (Table 2; “right façade #2” IT/right: 42, DT/left: 5, EL: 3; “left façade” IT/left: 42, DT/right: 6, EL: 2) do not support this hypothesis, as the compared distributions are not significantly different (*avant* $\chi^2(1)=2.096$, $p<.1477$; *devant* $\chi^2(1)=0.8$, $p<.7768$).

3. ILNs and factors: *avant/devant* and dynamic versus static function

ILNs identify parts by selecting specific properties of entities. It has already been mentioned (section 1) that these properties may have to do with

orientation (e.g., *avant* ('front'), *derrière* ('back surface'), *bas* ('bottom'), *gauche* ('left'), *côté* ('side'), etc.), topology (e.g., *intérieur* ('interior'), *bord* ('edge')) or distance (*extrémité* ('extremity'), *centre/milieu* ('centre/middle')). However, beyond these differences concerning categories of spatial information, ILNs that belong to the same “domain” (e.g., orientation) turn out to significantly diverge in the properties they select and/or the kind of processes these properties give rise to. For instance, data on ILNs related to vertical orientation (*haut* ('top'), *dessus* ('top surface'), *bas* ('bottom'), *dessous* ('underside')) and to lateral orientation (*gauche* ('left'), *droite* ('right'), *côté* ('side'))¹³ show that these markers call for semantic parameters that differ from those underlying frontal orientation (e.g., degree of lateralization) and/or bring into play calculi that are peculiar to the considered orientational axes (e.g., functional interaction and use, saliency/accessibility of a part).¹⁴

More crucially, ILNs falling within the same “domain” (e.g., orientation) and that are even related to the same “notion” (e.g., frontal orientation) can diverge in the way they select properties. We showed in section 2 that interpreting the ILNs *avant* and *devant* presupposes the calculation of a frontal orientation relying on four (possibly competing) parameters — aerodynamicity, saliency, static function and dynamic function— which can be partially ordered according to their influence in the process. Although both markers are sensitive to these factors, a thorough examination of *avant* and *devant* reveals noteworthy differences concerning their processing. This

section aims precisely at highlighting some of these differences. As shown below, *avant* is more tightly related to dynamic function and *devant* to static function. We demonstrate this difference between *avant* and *devant* with respect to static and dynamic functions by comparing the results obtained for the “standard” van previously mentioned (Figure 3a) to those corresponding to an “open-sided” van (Figure 3b).

3.1. Standard van and dynamic function

We saw in section 2.2.2 that, when presented with the standard van (Figure 3a) and with either *avant* or *devant*, many more subjects designated the left intrinsic side of this entity (dynamic function + aerodynamicity) than its right deictic side (saliency). These results show that the frontal orientations underlying both *avant* and *devant* give greater importance to dynamic function (and aerodynamicity) than to saliency. Therefore, *avant* and *devant* could be seen as behaving in a similar way with respect to dynamic function. However, the analysis of an open-sided van allowed us to throw new light on this question.

3.2. Open-sided van: introducing static function

The open-sided van (Figure 3b) has an opening on the right face, suggesting that it can be used as selling counter. The main difference with the standard

van thus concerns the combination of a static (selling) function and saliency on this right side, the left side remaining unchanged (dynamic function + aerodynamicity).

Here again a majority of subjects chose a frontal orientation based on the dynamic function (and aerodynamicity; left side/intrinsic interpretation) for both *avant* and *devant* (Table 3; *avant* IT: 37, IL: 6, EL: 7; *devant* IT: 32, IL: 14, EL: 3). However, this kind of “dynamic” orientation proved to be more massive for *avant* (37) than for *devant* (32). Conversely, the use of a frontal orientation based on the static function (and saliency; right side/“intrinsic lateral” interpretation) occurred more frequently for *devant* (14) than for *avant* (6). The comparison of each distribution with a random choice revealed a clear difference in the case of *avant* ($\chi^2(1)=12.94$, $p<.0003$) and a result approaching significance for *devant* ($\chi^2(1)=3.66$, $p<.0557$). Moreover, comparing the two distributions (*avant* and *devant*) showed that they were significantly different ($\chi^2(1)=5.35$, $p<.0207$). The latter result strengthens the divergences noted above: while *avant* is more closely related to the dynamic function than *devant*, *devant* is more sensitive to the static function than *avant*.

Beyond these differences between *avant* and *devant*, recall that dynamic function (and aerodynamicity) is dominant over static function (and saliency) when these ILNs are applied to the open-sided van. If we take into account the probable balance between aerodynamicity and saliency (no order; section 2.2.3), it follows that the dynamic function outmatches the

static function. This outcome complements the ordering of the factors already established in section 2.2.

3.3. *Standard and open-sided vans*

Bringing together the results of the standard van (Table 3; *avant* IT: 37, DT: 3, EL: 10; *devant* IT: 45, DT: 1, EL: 4) and those of the open-sided van (Table 3; *avant* IT: 37, IL: 6, EL: 7; *devant* IT: 32, IL: 14, EL: 3) provides further evidence that *avant* is more sensitive to the dynamic function (than *devant*), while *devant* is more sensitive to the static function (than *avant*). Indeed, comparing the distributions obtained with the standard versus open-sided vans for *avant* and *devant* showed that they were not significantly different for *avant* ($\chi^2(1)=.89, p<.3447$), whereas they were for *devant* ($\chi^2(1)=13.46, p<.0002$). This means that the static function added by the selling counter in the open-sided van influences the interpretation of *devant* but not that of *avant*.

4. Judgment task

Although the observations made so far were exclusively based on analyses of response distributions, the analysis of response latencies showed that the pointings were significantly more costly when a single interpretation arose

(coinciding factors) than when more responses were possible (competing factors) (t test, mean diff. =73.96 ms, diff. at $p<.05$ =50.58 ms, $p<.0042$). This can be easily explained by the fact that, in situations of “conflict”, subjects have to make a choice between several interpretations. However, in such situations, do all the subjects take into account the entire range of available interpretations? Our subjects participated in a second experiment, which is briefly described below.

This complementary experiment consisted of a judgment task in which subjects saw the following type of stimuli on a computer screen: an ILN together with a spatial entity in which a part had been highlighted (the pairs entity/ILN were exactly the same as in the pointing task).¹⁵ The subjects were asked to indicate by means of specific keys on the keyboard whether the visually highlighted portion of the entity corresponded or not to the associated ILN.¹⁶ They then had to put their finger back on a fixed point situated on the lower edge of the keyboard. The following stimulus (entity + ILN) appeared two seconds after they had pressed the key (stimuli were displayed in random order and each only once). For each pair entity/ILN, the true/false answer (key) and the response latency were recorded.

4.1. Response latencies

The most spectacular phenomenon that emerges when comparing the two experiments is the sharp increase of the response latencies in the judgment

task. For example, if we observe the parallelepipedic house with a right façade #2, the parallelepipedic house with a left façade, as well as the different square houses (right or left façade), the average response latency obtained in the pointing task (for *avant* and *devant*) was 691 ms whereas this average value rose to 1398 ms in the case of the judgment task. In other words, response latencies were multiplied by two from one task to the other. This increase in response latency is not surprising, given the nature of the tasks, particularly the fact that making judgments involves a more “metalinguistic” type of response than pointing. In particular, in the judgment task the subjects are faced with interpretations that they would (possibly) not have been led to make, whereas pointing leaves them free to process the ILNs in whatever way they wish (possibly not taking into account some plausible interpretations). The data discussed below give some insights into the processing which underlies these two kinds of tasks and allow a better understanding of this increase in response latency.

Table 4. Houses *avant* (judgment task)

Entity	T [†]		F		EL
	N	RL (ms)	N	RL (ms)	N
Paral. house right faç. #2 IT	49	1327	1	2373	0
Paral. house right faç. #2 DT	10	1374	40	1459	0
Paral. house left faç. IT	44	1369	3	1975	3
Paral. house left faç. DT	17	1341	32	1457	1
Square house right faç. IT	45	1492	5	1431	0
Square house right faç. DT	15	1415	34	1544	1
Square house left faç. IT	50	1321	0	0	0
Square house left faç. DT	4	2174	45	1557	1

[†] T: true, F: false, EL: eliminated, IT: intrinsic, DT: deictic, N: number of responses, RL: response latency.

Table 5. Houses *devant* (judgment task)

Entity	T [†]		F		EL
	N	RL (ms)	N	RL (ms)	N
Paral. house right faç. #2 IT	50	1196	0	0	0
Paral. house right faç. #2 DT	9	1682	41	1450	0
Paral. house left faç. IT	45	1315	5	1614	0
Paral. house left faç. DT	14	1355	36	1462	0
Square house right faç. IT	46	1378	3	1220	1
Square house right faç. DT	13	1480	35	1270	2
Square house left faç. IT	49	1206	1	973	0
Square house left faç. DT	4	1794	46	1457	0

[†] T: true, F: false, EL: eliminated, IT: intrinsic, DT: deictic, N: number of responses, RL: response latency.

4.2. Distributions

The distributions obtained in the judgment task clearly showed that a very large majority of subjects agreed with the intrinsic interpretation of the ILNs. The square house with a right façade (Figure 2d) is a good example of this finding (Table 4 (*avant*); Square house right faç. IT T: 45 (90%), F: 5 (10%), EL: 0; Table 5 (*devant*); Square house right faç. IT T: 46 (92%), F: 3 (6%), EL: 1 (2%)). The percentage of accepted IT interpretations recorded for the previously examined group of houses (section 4.1) — parallelepipedic house right façade #2, parallelepipedic house left façade, square houses— confirmed this observation (Table 4 and 5 (*avant/devant*); IT T: 378 (94.5%), F: 18 (4.5%), EL: 4 (1%)).

In contrast, a majority of subjects rejected a deictic interpretation of ILNs. Once again, the square house with a right façade is a good illustration of this point (Table 4 (*avant*); Square house right faç. DT T: 15 (30%), F: 34 (68%), EL: 1 (2%); Table 5 (*devant*); Square house right faç. DT T: 13

(26%), F: 35 (70%), EL: 2 (4%)). The percentage of rejected DT interpretations corresponding to the group of houses also supported the conclusion that most subjects ignored deictic interpretations (Table 4 and 5 (*avant/devant*); DT T: 86 (21.5%), F: 309 (77.25%), EL: 5 (1.25%)).¹⁷

In the judgment task, then, we find that subjects overwhelmingly accept intrinsic interpretations while most of them reject deictic readings. These findings allow us to partially answer our previous questions concerning the nature of the two tasks (pointing versus judgment) and the kind of processes which underlie situations of “conflict” (multiple responses) during the pointing task. Indeed, the fact that subjects accept intrinsic interpretations suggest that those who made a deictic choice in the pointing task also had in mind the intrinsic reading of the corresponding ILN. Furthermore, the fact that many subjects reject deictic interpretations seems to indicate that most of those who had interpreted an ILN in an intrinsic manner were not aware of its possible deictic processing. More generally, it turns out that in cases of conflicts during the pointing task (e.g., intrinsic/deictic choice), a majority of subjects did not take into account the entire range of existing interpretations.

5. Perspectives : frontal orientation and categorization of spatial entities

5.1. ILNs, component nouns and the distinction “location”/“object”

As mentioned in section 1, ILNs constitute a full-fledged category of spatial markers (Aurnague, 1996, 2004; Borillo, 1988, 1999). An important property of these linguistic units is their ability to denote a “space portion” adjacent to the material part they carve up in spatial entities. This phenomenon is illustrated by sentences like (4a) and (5a) in which the localized entity/trajector can be situated near the reference entity/landmark without these two elements being in contact (e.g., dirt on the wall above the door (4a), fly next to the rug (5a)):

(4 a/b) *Le haut de la porte est sale/La poignée de la porte est sale*

‘The top of the door is dirty/The door handle is dirty.’

(5 a/b) *La mouche est au coin du tapis/La mouche est sur la ganse
du tapis*

‘The fly is at/on the corner of the rug¹⁸/The fly is on the rug
braid.’

Moreover, the parts denoted by ILNs appear to be stable or fixed in the framework that is defined by the “whole” entity. Due to these properties (stability + adjacent space portion), spatial entities designated by ILNs have proved to match a general definition of “location” which also applies to geographical locations.

The analysis of ILNs also revealed the localizing character of these markers: their semantic content specifies the location of the designated part by means of topological, orientational or distance-related information (see sections 1

and 3). As a consequence, ILNs seem to refer to “specified locations” like proper nouns denoting geographical entities. These two categories of nouns turned out to have closely related syntactico-semantic patterns, as shown by their comparison in French and Basque (Aurnague, 1996: 165-166, 2004: 96).

“Component nouns” referring to functional parts of spatial entities (e.g., *pied* (‘leg’), *poignée* (‘handle’), *porte* (‘door’), *roue* (‘wheel’)) differ from ILNs with respect to most of these points. Although they also denote stable elements (within the whole entity), they are not usually able to designate a space portion next to this material part as illustrated in (4b) and (5b) (dirt cannot be somewhere near the handle (4b) and the fly (5b) is necessarily in contact with the braid (*à* (‘at’) not possible)). So, functional parts do not fulfill the definition of locations previously mentioned (stability + space portion) and are better characterized as “objects”.¹⁹

Furthermore, the semantic content of component nouns mostly underlines the function of the described parts and does not directly inform of their location.²⁰ This clearly contrasts with the spatial and localizing nature of ILNs.

Beyond these oppositions, ILNs and component nouns seem to define in many languages a synchronic and diachronic continuum, the former markers deriving from the latter through different semantic and cognitive patterns (e.g., anthropomorphic, zoomorphic, environmental models) (Svorou, 1994: 70-89). This evolution often entails some kind of grammaticalization

process, ILNs being more “fossilized” than component nouns (Aurnague, 1996: 180-185, 2004: 101-104; Borillo, 1999: 73-75; Svorou, 1994: 100-109).

5.2. Factors/properties and categorization of spatial entities

Linguistic and psycholinguistic studies, such as the one presented here, aim at better understanding how the nature of spatial configurations conditions the interpretation of the spatial lexicon (here ILNs and, to a lesser extent, component nouns). Within such a framework, one could rightfully question whether all the conditioning factors or properties brought to the fore are likely to give rise to classes or categories of spatial entities.

Owing to their contingent character, it seems reasonable to think that the factors which partially or totally rely on contextual elements do not really categorize spatial entities. This is the case of aerodynamicity and geometrical saliency which depend on some internal characteristics of entities (e.g., existence of a larger dimension, surface area of sides), but are also conditioned by more ephemeral parameters from the context (e.g., largest dimension in the horizontal plane, angle of presentation of sides). On the contrary, factors such as static or dynamic functions, which mostly involve the intrinsic properties of entities, appear to be better candidates for a possible categorization.

Hence, a first answer to the question previously raised is that not all of the factors that play a role in the semantic content of spatial expressions systematically lead to the emergence of a class of entities. However, beyond the contextual/non contextual opposition mentioned above, are there some additional criteria available to differentiate internal (non contextual) properties according to their categorizing ability?

Following studies on grammaticalization (Heine et al., 1991) and analyses concerning the structures of spatial descriptions (Talmy, 1983, 2000), a promising direction of research may consist in exploiting the distinction between lexical (open-class) and grammatical (closed-class) elements.

From this viewpoint, component nouns appear to constitute an open and possibly unlimited class of lexical units (additional lexemes can always be created for referring to parts of new entities). The functional properties they select often apply to a (more or less) narrow range of entities (e.g., lid → container; switch → electrical appliance/system; wheel → vehicle, mobile entity) and thus it is not possible to combine these markers with any kind of whole (Aurnague, 1996: 176, 2004: 97). As a consequence of these characteristics (numerous lexemes, possibly unlimited creations, specific content), component nouns split the domain of entities into a large number of subclasses (entities with lids, switches, wheels, doors, handles, legs, etc.) and the corresponding (internal) properties do not seem to be good candidates for cognitive and semantic categorization.

In contrast to component nouns, ILNs constitute a semi-closed class of spatial markers (Aurnague, 1996, 2004; Borillo, 1988, 1999). This peculiarity of ILNs is strengthened by their limited number (and restricted emergence process) and is also reflected in their ability to enter into grammatical constructions such as prepositional phrases containing *à* (at) in French (e.g., *à gauche de* ('on the left of'), *à l'angle de* ('at the corner of'), *au milieu de* ('in the middle of')). From a semantic point of view, it was underlined that ILNs apply to entities according to a restricted set of topological, orientational and distance-related properties (sections 1 and 3). The range of whole-entities to which these markers can be associated — through the fulfillment of the properties mentioned— is much wider than in the case of component nouns: an ILN like *haut* ('top') combines, for instance, with nouns denoting geographical locations (*montagne* ('mountain')), buildings (*maison* ('house')), artefacts (*chaise* ('chair')), natural objects (*rocher* ('rock')), etc. To sum up, ILNs are based on a limited number of internal properties which can apply to a large range of elements (a pattern that clearly contrasts with component nouns). Due to these two characteristics (limitedness and generality), the semantic properties underlying ILNs are more likely to play a part in a possible categorization of spatial entities.

Among the notions shared by ILNs, we have already pointed out the immaterial/material opposition as well as the property of being stable or fixed in a given frame of reference (notions which underlie the opposition

between “locations” and “objects”). Internal factors like dynamic function (specific arrangement of parts according to the usual direction of motion) or static function (interactive side with features) revealed by the study of *avant/devant* could also be considered as possible parameters in cognitive and semantic categorization of spatial entities (these two factors being subsumed by the notion of intrinsic front).

More generally, using the opposition between lexical and grammatical elements as a criterion by which to isolate categorizing factors leads to the selection of high-level or general properties (e.g., topological, orientational or distance-related parts) rather than more specific ones (e.g., components). The synchronic and diachronic continuum from component nouns to ILNs provides a good illustration of how high-level notions (e.g., intrinsic front) can emerge from quite specialized ones (e.g., face, eye, forehead). Grammaticalization and “abstraction” seem here to be intimately related phenomena. The preference for a restricted set of general properties (rather than for a wide range of specific parameters) demonstrated by grammaticalization coincides, in any case, with the theoretical choice of parsimony guiding many ontological studies in philosophy or, even, in artificial intelligence (e.g., see Varzi’s paper in this volume).

In the long run a cross-linguistic research on grammatical markers of space should provide an inventory of the concepts governing the categorization of spatial entities through languages (this collection of concepts should be limited (Talmy, 2000: vol. 1, ch. 1)). It should also give some clues about

the degree of generality (more or less widespread, universal, etc.) of each concept in language and cognition.

Notes

¹ This research was carried out within the project “Spatial entities and their categorization in language and cognition” (COG135; 1999-2001) that was financially supported by the Program “Cognitique” of the French Ministry of Research. We would like to thank Harriet Dunbar and Maya Hickmann for their stylistic advice and comments on a previous draft of this paper.

² Thus, deictic cases are sensitive to possible rotations of the viewer who orients the landmark, whether they involve three elements (trajector, landmark, viewer) as in (3) or two elements (trajector/viewer, landmark) as in *Je suis devant l'arbre* (‘I am in front of the tree’). These cases differ from (other) contextual situations in which the orientation of the landmark is based on parameters which are independent of the viewer, like the configuration of the yard in sentence (2). Indeed, (2) is not very different from “absolute” contextual orientations which call for properties or elements of the geographical framework (mountains, sea, winds, compass points, etc.). Note that in some (contextual) viewer-free descriptions such as *La tente est devant l'arbre* (‘The tent is in front of the tree’, for a tent whose entry is facing the tree), the orientation of the landmark can directly follow from the (inanimate) trajector.

³ Before this experiment, a first series of tests was carried out with exactly the same protocol (pointing task) (Aurnague et al., 2000). This previous series —that was submitted to 47 subjects from the “Université de Toulouse-Le Mirail” (mean age: 31.17 years, 18 males, 29 females)— only differs from the present experiment in the nature of the geometrical and functional entities that were presented as stimuli (e.g., parallelepiped standing up #1 (Figure 1a), parallelepiped lying down #1 (Figure 1b), parallelepipedic

house with a right façade (Figure 2a)). A few results from this previous series of tests will be used here.

⁴ A first series of tests (see note 3) and a preliminary testing of the present experiment allowed us to check that the representations/drawings of spatial entities (2 dimensions) were correctly interpreted (in 3 D) and that the functional properties of the computer (in particular its orientation) did not interfere with the task of assigning orientations to the displayed entities.

⁵ Functional entities (houses (Figure 2), vans (Figure 3)) led to intrinsic or deictic interpretations of *avant* and *devant*, whereas geometrical shapes (parallelepipeds and cube (Figure 1)) gave rise to two distinct deictic choices (right front, left front). The latter point follows from the fact that most entities were displayed slantwise, with a vertical edge and two sides facing the subject.

⁶ Differences in saliency between the two parallélépipèdes standing up can be grasped by comparing in each case the angles formed by the vertical/central edge with the inferior (horizontal) edges of the right and left sides. While these two angles are roughly equal for the parallélépipède standing up #1, the right angle is greater than the left one for the parallélépipède standing up #2.

⁷ In a study of dimensional nouns, Vandeloise (1988: 411-412) described the various uses of the word *longueur* (length) and proposed the existence of a “pragmatic bridge” between uses which designate the entity’s largest dimension on the horizontal plane and those which refer to the direction of a mobile entity: “this [pragmatic] bridge... is based on the aerodynamic character of moving objects. Indeed, an object offers less resistance to air if its longer dimension is parallel to movement”.

⁸ The hits/responses that did not match any of the possible interpretations (in terms of x/y positions), as well as those whose latencies were higher than 4000 ms or lower than 200 ms, were eliminated (EL).

⁹ An equivalent cube without saliency (neutral configuration) was not available in the experiment. As a consequence, the distributions of the “salient” cube are examined with respect to a virtual neutral cube with a 50%-50% distribution.

¹⁰ Although one would expect that the right side of the parallelepipedic house (right façade #1) combines static function with saliency, this does not seem to be the case. The angle of presentation of the sides is crucial in assessing geometrical saliency (angles formed by the vertical edge near the viewer and the horizontal edges of the right/left sides). On this basis, the parallelepiped lying down #1 (geometrically equivalent to the house; Figure 1b) appears to be closer to the parallelepiped standing up #1 (no saliency; Figure 1a) than to the parallelepiped lying down #2 (right salient side; Figure 1d) which can be related to the parallelepiped standing up #2 (right salient side; Figure 1c). Recall that the parallelepiped standing up #1 and the parallelepiped standing up #2 differed by virtue of saliency (on the right side) and gave rise to significantly different distributions (cf. section 2.1.2).

¹¹ Even so, configurations that distinguish dynamic function and aerodynamicity might be devised (such as a special vehicle whose largest dimension would be perpendicular to the direction of motion) so as to tackle the interaction between these properties.

¹² A certain tendency to favor aerodynamicity could be noted (in particular for *avant*) but it was not significant.

¹³ These data stem from a previous series of tests (Aurnague et al., 2000) and a preliminary analysis of the considered ILNs in the present experiment.

¹⁴ This does not preclude cases of (indirect) interaction between ILNs. In particular, it is well-known that the calculation of a lateral orientation implies to identify an associated frontal direction (Aurnague et al., 2000).

¹⁵ However, the total number of stimuli was higher than in the pointing task because, for each pair entity/ILN, the different possible interpretations (highlighted parts of the entity) had to be introduced, giving rise to several stimuli. Moreover, in order to include

distractors, parts of entities that could not be designated by an ILN (whatever its interpretation) were also presented during the task.

¹⁶ The specific keys were “V” for True and “N” for False on a French “azerty” keyboard.

¹⁷ As proposed by a reviewer, and following our previous remark about the possible “metalinguistic” nature of the judgment task, it could be the case that in this second experiment some subjects did not consider themselves part of the communicative situation (they would have acted as if they were merely part of the experiment, with a more “external” point of view with respect to the localization process), leading to this higher level of rejection of deictic interpretations. However, this assumption cannot be easily checked and we prefer not to take it into account.

¹⁸ For most speakers, the English translation based on the preposition *on* implies the existence of a contact between the trajector and the landmark. However, spatial descriptions associating an ILN with the preposition *at* (e.g., *The lamp is at the end of the table*, *The cloud is at the top of the mountain*) usually admit both an interpretation in which the trajector and the landmark are in contact and an interpretation in which they are not.

¹⁹ As a probable consequence of their functional nature and their lack of associated space portions, components are very often better delimited than parts denoted by ILNs.

²⁰ However, location can sometimes be “pragmatically” deduced from knowledge about the typical (internal) structure of an entity, its canonical position, etc.

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