SPACE IN LANGUAGE
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(editors)
1. INTRODUCTION*

Languages differ a great deal in how they organize spatial information. For example, languages either lexicalize or grammaticalize information concerning motion, thereby highlighting some types of information more than others. More specifically, Talmy (2000) proposes a distinction between two types of languages: satellite-framed and verb-framed languages (e.g., Germanic vs. Romance languages). Thus, when expressing motion, a satellite-framed language such as English lexicalizes the Manner of motion in the verb (e.g., to run, to fly), using satellites (e.g., the particle up) to express Path information within one compact structure, as illustrated in examples 1a and 1b:

(1) a. He is running up the hill.
b. The baby is crawling across the street.

In contrast, a verb-framed language such as French lexicalizes Path in the verb root (e.g., monter ‘to ascend’), leaving Manner information implicit or placing it at the periphery of the sentence, for instance by means of gerunds (e.g., en courant ‘by running’) or of adverbials (e.g., à quatre pattes ‘on all fours’), as illustrated in examples 2a and 2b:

(2) a. Il monte la colline en courant.
Lit. ‘He is ascending the hill by running’.
b. Le bébé traverse la rue à quatre pattes.
Lit. ‘The baby is crossing the street on all fours’.

Such striking differences are of great relevance for the study of spatial cognition and have led to some debates opposing two main approaches concerning the relation between language and cognitive processes. The universal

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hypothesis suggests that spatial cognition is based on universal perceptual and
cognitive processes that are independent from language-specific properties. According to this view, no deep cross-linguistic differences are therefore expected at the level of speakers’ mental representations. In contrast, the relativity hypothesis suggests that language-specific factors partially affect how speakers construct spatial representations, because languages provide filters that channel incoming information, making different aspects of reality more salient and accessible. In this view, language-specific performances are therefore expected and such differences should affect performance beyond language.

Most studies showing language effects have been based on analyses of language use (Bowerman and Choi 2001; Hickmann et al. 2009; Slobin 2004), with the notable exception of some research concerning infants (e.g., Bowerman and Choi 2003). In contrast, studies examining non-verbal performances either report no language effect or effects that are less clear and/or viewed as being relatively superficial (Gennari et al. 2002; Landau and Lakusta 2006; Papafragou et al. 2008). It therefore remains to be shown whether typological differences affect speakers’ conceptual representations beyond language itself, requiring other measures in order to access speakers’ internal representations (such as co-verbal gestures, non-verbal categorization, memory, or on line eye tracking during production).

This debate therefore presents a great challenge in need of an empirical basis that would allow us to distinguish among several hypotheses. Although most approaches (including both the universal and relativity hypotheses) might agree that typological differences might affect speakers’ linguistic performance, the major question to be addressed if we want to test the above hypotheses is to determine the extent to which such language differences go beyond language use. Thus, the absence of language effects on speakers’ performance in non-verbal tasks would either not support the relativity hypothesis or at best support a ‘weak’ version of this hypothesis. In contrast, the finding that differences in linguistic performance are accompanied by differences in non-verbal performance would support a ‘strong’ relativity hypothesis.

In the context of this debate, we conducted a study that elicited verbal and non-verbal responses from the same subjects and about the same motion events. In particular, this study investigated the extent to which the properties of two typologically contrasted languages (French and English) would constrain how speakers performed in several tasks that provided different measures of their cognitive processes: how they described motion events (production task) and how they allocated attention when exploring these events during production (eye-tracking); how they categorized these events non-verbally in the absence of any relevant linguistic information (non-verbal categorization); how they categorized these events non-verbally when the stimuli included some
linguistic information (verbal categorization).

The study addresses two general questions: (1) Does speakers’ linguistic performance differ in the production task and how important are these differences? (2) If an important language effect is found in this task, does it go beyond linguistic production and affect other measures and/or tasks? Furthermore, the design was constructed in such a way as to allow us to test several hypotheses. At one extreme, it might be predicted that no major language effects should be found in any task, including in the production task where possible differences might be shown to be merely superficial (null hypothesis). At the other extreme, language-specific preferences might be found in all tasks, regardless of whether they elicited verbal and non-verbal responses, and regardless of the verbal vs. non-verbal nature of the stimuli (strong relativity hypothesis). Between these two extremes, the data might also support one of two intermediate versions of the relativity hypothesis. Speakers might behave quite differently in their linguistic performance (production task), but not in any of their non-verbal responses as measured in the present study by both categorization tasks (weak hypothesis). Finally, language effects might be observed in production, as well as in tasks that require non-verbal responses but only when relevant linguistic information was simultaneously provided, as was the case in our verbal categorization task (moderate hypothesis).

2. METHOD

2.1. Participants

The study included 28 native speakers of French and English (14 per language, all right-handed). Inclusion criteria included the following: (1) participants had to be native, monolingual speakers of English or French, (2) they had to be above 18 years of age, and (3) they had to report no known disorders or deficits (no psychiatric disorders, no seeing or hearing impairment, and no known history of developmental reading/oral language difficulties). All participants were asked to fill out a questionnaire about their language background. They all had been exposed to only one language since birth and had not learned any foreign language before at least age 10 (compulsory teaching at school). None had lived in a foreign country for more than six months.
2.2. Materials

Testing involved three tasks: non-verbal categorization, production, and verbal categorization, all coupled with an eye-tracking paradigm. These tasks involved two sets of stimuli all of which showed voluntary motion. The first set (hereafter video clips) consisted of video films in which six actors (three men and three women) performed displacements in different scenes (either outdoors or indoors) that varied along Manner and Path. Six types of Paths were selected (up, down, into, out of, across, along), as well as six types of Manners that either involved the use of an instrument (bicycle, scooter, rollers) or involved no such instrument (run, jump, crawl). The use of an instrument was expected to be most effective in distinctly focusing speakers’ attention on Manner, particularly for the purpose of measuring eye-movements. An additional Manner was included in some items (walk) as it was assumed to be most ‘neutral’ and to attract the least attention on Manner (given that all characters were human). A partially crossed design combined these Manners and Paths across video clips (also see more details below). The second set of stimuli (hereafter cartoons) consisted of animated drawings showing characters performing displacements in different Manners (e.g., walking, swimming, climbing a tree) along three types of Paths (up, down, across). This second set provided more vivid and more varied stimuli (humans and animals, diverse settings).

2.3. Production task

Both sets of stimuli (video clips and cartoons) were used in the production task. There was a total of 43 items (2 training, 10 video clips, 18 cartoons, 8 controls and 5 distractor items) that were presented to all subjects. Stimuli from the two sets were interspersed in a mixed list of items and presented in a pseudo-randomized order. After they saw each stimulus, participants were asked to describe what had happened.

The analysis examined three aspects of their verbal responses: the number of information components they expressed (hereafter density), the types of information they selected to express (focus), and the means whereby they expressed this information in their responses (locus). In the present study, particular attention was placed on whether subjects expressed only Manner information (M-responses), only Path information (P-responses), or both types of information (MP-responses). In addition, the analysis examined whether they used verbs vs. other devices (particles, prepositions) to express each type of information.

1 For our purposes here, only the eye-movements that were collected during the production task are presented. Ongoing analyses presently examine eye-movements across the categorization tasks.
of information. Our prediction was that speakers should produce structures that are based on the features of their language. More specifically, the following predictions were made: 1) although they should express Path in both languages, they should add Manner information more frequently in English than in French; 2) English responses should contain Manner verbs and other devices marking Path, whereas French responses should mostly contain Path verbs and fewer other devices than English responses. As a result, English descriptions should show a higher level of semantic density, since English speakers should mostly produce MP-responses (two expressed information components, i.e., density 2, hereafter SD2), whereas French speakers should mostly produce P-responses (SD1).

The analyses below also include the eye-movement data that were collected during the production task. Subjects’ eye-movements were recorded with a portable eye-tracker while they were exploring the videos and cartoons during production in such a way as to measure their attention to various aspects of these events. The question addressed was as follows: Do subjects pay more or less attention to Manner and/or to Path depending on the specific properties of their language? We present below data concerning subjects’ fixations in order to examine whether they paid attention to the following Areas of Interest (AoI): Source (S), Goal (G), Path (P) and Path+/Manner (P+/M), as illustrated in Figures 1 and 2 for video clips and for cartoons respectively. Note that it is difficult to differentiate Manner from Path for some fixations (therefore the mixed AoI P+/M).

Figure 1. Areas of Interest (video) - S: Source, G: Goal, P: Path, P+/M: Path with or without Manner
2.4. Non-verbal categorization task

For this task only the video clips were used. Stimuli were digitized at 25 frames/sec, 1008 Bitrate kbps, 384:288 scale size and 4:3 aspect, digitally edited and stored on a computer disk. On the basis of these films 30 main triad trials were constructed, as shown in the appendix. The procedure was as follows for each trial. Participants first saw a short target video showing a motion event performed in a certain Manner and along a certain Path (for example Enter-Bicycle in (3a)). The target video then disappeared and was followed by two other videos, variants of the target that differed from it with respect either to Path or to Manner (e.g. Exit-Bicycle and Enter-Scooter in (3b) and (3c)).

(3)  
   a. Target Video Enter-Bicycle: a woman entering a building on a bicycle  
   b. Variant Video 1 Exit-Bicycle: a woman exiting a building on a bicycle  
   c. Variant Video 2 Enter-Scooter: a woman entering a building on a scooter

Participants were asked to choose the variant that looked most like the target and to press a key as fast as they could to indicate their choice. Note that
there was no correct answer in any main trial, so that subjects’ responses reveal their preferences in using \textit{Manner} or \textit{Path} as the criterion for categorization. The task started with three training trials to ensure that participants understood the task, followed by the main triads, to which 14 control and 7 distractor items were added, resulting in a total of 54 items, presented in a randomized order.\footnote{Control items consisted in triads constructed with the same video clips as the main items. The procedure was the same as for the main triads, except that in this case one of the two variants proposed in the control items corresponded exactly to the target video displayed at the beginning of each item. Control items allowed us to check whether our participants’ responses were biased or not. Distractor items consisted in triads of cartoons of motion events where the protagonists were non-animated objects (balls and boxes). These items were introduced to vary the material shown and to avoid any possible bias in response strategies.}

2.5. \textit{Verbal categorization task}

The verbal categorization task was exactly the same as the non-verbal categorization task, except that the target video was replaced by a target sentence presented auditorily at the same time as the two video variants. Stimuli were digitized at 44 KHz and 16 bits. Sentences were recorded by two female native speakers (of French and of English respectively) and they contained both \textit{Path} and \textit{Manner} information, as illustrated by the target sentences shown in (4a) for French and English respectively. Participants were asked to choose which variant video (for example (4b) or (4c)) was best described by the target sentence and to press a key to indicate their choice as fast as they could. Subjects’ responses show their \textit{categorical preferences}, i.e., their preferred reliance on \textit{Manner} or on \textit{Path} as criterion. The question was to determine whether categorical preferences followed language properties. If so, French speakers should choose the \textit{Path} criterion, whereas English speakers should either choose the \textit{Manner} criterion or show no preference for one or the other criterion.

\begin{itemize}
\item \textbf{a. Target Sentence}\\
French sentence \textit{Enter-Bicycle} : «On voit quelqu’un qui entre en vélo.} (Lit. ‘One sees someone entering by bike.’)\\
English sentence \textit{Enter-Bicycle} : «There is someone cycling in.}
\item \textbf{b. Variant Video 1} \textit{Exit-Bicycle} : a woman exiting a building on a bicycle
\item \textbf{c. Variant Video 2} \textit{Enter-Scooter} : a woman entering a building on a scooter
\end{itemize}
2.6. Procedure

The three tasks were presented successively in a fixed order. Testing always started with the non-verbal categorization task, followed by the production task, and then by the verbal categorization task. The rationale for this task order was three-fold. First, it was essential for the non-verbal categorization task to be presented first, since this task was meant to elicit non-verbal responses that would involve no linguistic input of any kind. Second, in contrast to the non-verbal categorization task, the verbal version of this task was meant to elicit non-verbal responses that would involve linguistic input (target sentences). Third, it was essential for the production task to occur before the verbal categorization task in order for subjects’ descriptions not to be influenced by the target sentences presented during this task.

3. Results

Given our aims, particular attention is placed below on determining whether language effects could be observed in each task. Recall that our major aim was to examine response patterns across tasks in order to test several hypotheses that differed with respect to their predictions concerning such effects in verbal vs. non-verbal tasks: 1) the null hypothesis predicts no language effect in any task; 2) the strong hypothesis predicts an effect in all tasks; 3) the weak hypothesis predicts an effect only in the production task; 4) the moderate hypothesis predicts an effect in the production task as well as in the verbal categorization task that involved processing relevant linguistic information.

3.1. Production task

3.1.1. Verbal responses in the production task

Figure 3 shows the types of information components that were expressed by verbs vs. other devices (particles, prepositions): Path (P), Manner (M), both (PM), or neither (none). These results are in line with the prediction that language-specific properties affect the density, focus, and locus of information in speakers’ responses. French speakers mostly produced Path verbs and provided less information in other devices (example 4a), whereas English speakers used compact and dense structures that systematically expressed Manner in verbs and Path in other devices (example 4b). As a result, the semantic density of subjects’ responses was higher in English than in French:
90% of English responses encoded both Path and Manner (MP responses, SD2); in comparison, only 55% of French responses were of type SD2, while 45% only contained one type of information, mostly Path (P-responses, SD1).

(5) a. *C’est une fille qui rentre dans la maison.*  
    [Path in the verb, no Manner]  
    (‘It’s a girl who is entering into the house’)

b. *There’s a girl jumping up the hill.*  
    [Manner in the verb, Path in satellite]

![Figure 3. Information expressed in verbs vs. other devices in French and English; PM: Path and Manner, P: Path, M: Manner](image)

3.1.2. Eye-movements during the production task

The results concerning eye-movements during the production task differ across the two sets of stimuli showing a language effect with the cartoons, but not with the video clips. Thus, the results for the video clips show no significant language difference in speakers’ attention allocation to any of the AoI; they therefore do not support the strong hypothesis. However, the results for the animated cartoons did show a language effect in how eye-movements unfolded during the task. In particular, Figures 4 and 5 show the time line of eye-movements from the beginning to the end of the stimuli in each language. These figures show that speakers paid more attention to Path in French than in English, at least from a certain point in time onwards during processing (at around 4500 msec). The effect of item set on eye-movements was not expected
and raises some methodological questions, to which we return below in the discussion.

Figure 4. Timeline of French fixations during the cartoon item: ‘a bear climbs up’

Figure 5: Timeline of English fixations during the cartoon item: ‘a bear climbs up’

3.2. Non-verbal categorization task

Figure 6 shows the percentages of responses in the non-verbal categorization task that were based on \textit{Path} vs. \textit{Manner} criteria in each language. Student t-tests showed the following results. First, there was a main criterion effect for French participants ($t(13)=3.72$, $p<0.005$) whereby they preferred \textit{Path} choices to \textit{Manner} choices. In contrast, there was no significant criterion effect for English participants ($t(13)=1.05$, $p>0.3$), nor any significant language effect on \textit{Manner} responses ($t(26)=1.55$, $p>0.1$). Thus, if we compare \textit{Manner} responses across languages, the difference between English and French is not significant.
3.3. Verbal categorization task

Figure 7 shows the percentages of responses in the verbal categorization task that were based on Path vs. Manner criteria in each language. Student t-tests carried out in this task showed the following results. First, there was a main criterion effect both within and across languages. English speakers showed a significant preference for Manner choices ($t(13)=3.59, p<0.005$), whereas French speakers continued to show a significant preference for Path as in non-verbal categorization task ($t(13)=2.19, p=0.04$). Comparing Manner choices across languages in this task shows a significant language effect ($t(13)=4.17, p<0.001$) with an advantage for English over French. Note also that Manner choices were more frequent in both language groups when categorization was verbal (Figure 7 below) rather than non-verbal (Figure 6 above).
4. GENERAL DISCUSSION

The present study examined the extent to which the properties of two typologically contrasted languages (French and English) would constrain how speakers performed in several tasks that elicited verbal and/or non-verbal responses on the basis of two set of visual stimuli that showed voluntary motion events (video clips and animated cartoons): a production task (describing these events) during which we measured attention allocation (eye-tracking); a non-verbal categorization task (categorizing events in the absence of any relevant linguistic information); and a verbal categorization task (categorizing events when linguistic targets were included among the stimuli).

Our major aim was to examine response patterns across tasks in order to determine whether language effects would occur, as well the relative strength of such effects beyond language use. In particular, the following hypotheses were tested: 1) a null hypothesis, according to which no major language effects should occur in any task; 2) a strong relativity hypothesis, according to which such effects should occur in all tasks; 3) a weak hypothesis, according to which language should affect production, but not any non-verbal response (verbal and non-verbal categorization); 4) a moderate hypothesis, according to which language should affect verbal and non-verbal responses but only when subjects had to process relevant linguistic information (production, verbal categorization).

The data from the production task were analyzed in two ways: analyses focusing on the nature of subjects’ responses and analyses of their eye-movements as they were exploring the scenes during production. Subjects’ linguistic performance differed in French and in English with respect to three aspects of their responses, namely the focus, locus, and density of expressed information. English speakers used compact and dense structures that expressed both Manner and Path information (MP-responses) and in which they systematically encoded Manner in verbs and Path in other devices. In contrast, French speakers mostly focused on Path information (P-responses) and expressed this information in the verb, and they provided less information about Manner in either loci and/or did not use any other devices in the verbal network. As a result, semantic density was higher in English than in French. These patterns directly follow from language-specific factors that differentiate English and French as Satellite-framed vs. Verb-framed languages. These findings are therefore in line with the relativity hypothesis, although non-verbal behaviours are necessary to determine which version of this hypothesis they support (strong, weak or moderate).

The eye-movement data during the production task showed an unexpected difference in performance as a function of item set. The results for the
animated cartoons showed a language difference in speakers' attention allocation to different AoIs. In particular, the data reveal a difference in how eye-movements unfolded during the task in the two language groups: English speakers paid as much attention to Path and to Manner, whereas French speakers began to focus more attentively on Path towards the middle of the task. In contrast, with the video clips no significant difference was found in speakers' attention to any of the AoI and at any point during the task. In summary; the overall findings from the production task suggest a clear language effect in verbal responses, but only a partial language effect in the eye-movements data.

Turning now to the non-verbal categorization task, the results showed that French participants preferred Path to Manner as their categorization criterion, while English participants showed no significant preference for Path or Manner. In addition, the data showed no significant language effect with respect to the frequency of Manner responses in French vs. English. These results partially follow from the typological properties of each language. The preference for the Path criterion in French follows from the fact that this information is typically lexicalized in verbs, leading speakers to pay more attention to this information component. In contrast, English participants showed no preference for Path or Manner as criteria, a result which is related to the fact that English relies on compact and dense structures that systematically contain both types of information (Manner is lexicalized in the verb together with Path information in other devices), making them equally salient. However, this difference in response patterns was not sufficient to result in a significant language effect on the frequency of Manner responses: although Manner responses tended to be more frequent in English than in French, this difference was not significant.

Finally, Manner choices in categorization were more frequent for both language groups in the verbal categorization task as compared to the non-verbal categorization task. In addition, in the verbal version of our categorization task, English speakers showed a significant preference for Manner choices, whereas they showed no significant preference for Path or Manner in the non-verbal version. In contrast, French speakers showed a significant preference for Path in the verbal version, as they did in the non-verbal version. Finally, in the verbal categorization task Manner choices showed a significant language effect such that English speakers chose the Manner criterion significantly more than French speakers. Thus, regardless of language, the introduction of a linguistic stimulus (target sentence) to be compared with two visual stimuli increased the saliency of Manner information in this task resulting in an increased focus on Manner. Nonetheless, although French speakers focused more on Manner in this task as compared to the non-verbal categorization task, they continued to pay more attention to Path information,
following in this respect the pattern of their language (*Path* lexicalized in the verb, *Manner* implicit or peripheral).

On the basis of these results, let us now return to the different hypotheses explored above to see whether we can tease them apart. Our study first does not support the *null* hypothesis according to which no major language effects should be found in any task. Thus, the production task clearly shows cross-linguistic differences in how subjects described motion events and these differences are of at least three types (focus, density, locus): subjects do not choose the same information (*Path* in French, *Path+Manner* in English), resulting in utterances of varying semantic density (English > French), and they use different structures to organize the selected information (*Path* verbs and no *Manner* in French, *Manner* verbs and *Path* satellites in English). In this respect, it is important to note that language-specific factors do not ‘force’ speakers to construct these structures (which would make language differences trivial), since their native language provides several other grammatical options to describe the same events. For example, it would be perfectly grammatical to use a *Manner* verb in French (*Il court en montant à l’arbre* ‘He runs climbing the tree’) or a *Path* verb in English (*He is crossing the street running*), but such utterances would be quite atypical and marked. Rather, languages strongly invite speakers to rely on those available structures that constitute the most typical and accessible ways of organizing information, thereby also inviting them to pay more or less attention to different types of information.

Second, comparisons across tasks do not support either the strong or the weak relativity hypothesis. Thus, according to these views, language-specific preferences should occur in all tasks (strong hypothesis) or they should occur in verbal tasks but not in non-verbal tasks (weak hypothesis). As we saw, language effects were found in some tasks but not in others and, furthermore, a language effect was found with some non-verbal measures (eye-movements, categorization). Thus, typological language properties clearly affect how speakers express motion (production task), they can generate different categorical choices in the verbal and non-verbal categorization task, and they partially constrain attention allocation during subjects’ exploration of visual stimuli. Our results therefore support the *moderate* version of the relativity hypothesis which predicts language effects on verbal responses, as well as on non-verbal responses that involved the processing of relevant linguistic information.

Two final methodological points should be noted. First, in order to interpret the language effect that was found with the verbal categorization task, as well as the enhanced focus on *Manner* information that was observed for both language groups in this task as compared to the non-verbal categorization task, it must be recalled that the target sentences encoded both *Manner* and *Path* (see
examples 3a and 3b above: *There is someone cycling in, On voit quelqu’un qui entre en vélo*). Ongoing research presently examines whether such effects can also be observed with other sentence types, particularly sentences that only provide *Manner* (e.g., *There is someone cycling, On voit quelqu’un qui fait du vélo*) or that only provide *Path* (e.g., *There is someone entering, On voit quelqu’un qui entre*). Second, the fact that a language effect was found on attention allocation during the production task with one set of items (cartoons) but not with the other (video clips) raises some questions concerning the nature of the stimuli. Among other explanations for this unexpected finding, note that cartoons told a little story that was perhaps more ‘interesting’ and/or ecological than the video clips. It is therefore possible that factors such as vividness and coherence may play a role in the salience of some types of information, thereby influencing attention allocation.

5. CONCLUDING REMARKS

Recent debates concerning the relation between spatial language and spatial cognition have opened new challenges in the Cognitive Sciences. In the context of these debates, our study hopefully makes a tentative contribution that might help tease apart different hypotheses. We examined speakers’ verbal and non-verbal responses in various tasks that required speakers to construct representations of motion events. The results show important differences in their linguistic representations, but also in their representations beyond language use as revealed by non-verbal measures that indicate how they allocate attention and how they preferentially categorize events. Many additional research directions are still necessary before definitive conclusions can be reached. It is clear that the use of multiple methodologies will be an essential and most certainly a necessary piece of the puzzle. The complexity of the findings that emerge from such combined methodologies show that hypotheses must be precisely formulated rather than contrasted in simplistic ways and that there will probably be no simple answers to the question of how to relate language and cognition.

REFERENCES


**APPENDIX**

Manners and paths selected for the Main triads in the categorization tasks

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<tr>
<th>N°</th>
<th>TARGET</th>
<th>CHOICES</th>
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<td>run-down/ jump-up</td>
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<tr>
<td>29</td>
<td>bicycle-out of</td>
<td>bicycle-into/ rollers-out of</td>
</tr>
<tr>
<td>30</td>
<td>scooter-down</td>
<td>scooter-up/ bicycle-down</td>
</tr>
</tbody>
</table>