Are modal representations automatic ingrained when processing the meaning of motor concrete Spanish verbs?

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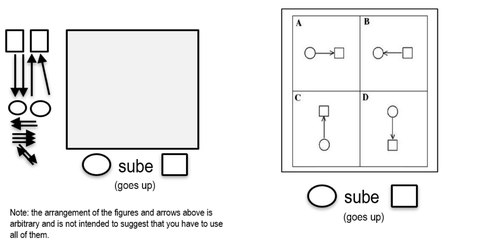
Introduction

The embodied theories of meaning suggest that the understanding of language is based on representations of a perceptual nature that prepare the subject for action (Fischer & Zwaan, 2006). The modal representations propose that understanding occurs through a corpus of cognitive processes where perception, language and action intervene. Richardson et. al. (2003) evidenced for English and (Moreno & De Vega, 2006) for Spanish, that these representations outline the spatial characteristics of the events. Thus, for example, it is expected that the verb SUBRAYAR (underline) can be systematically figured out as a movement on a lateral axis because of the form of this action over the lines of a text. Then, motor verbs offer an opportunity to evaluate the existence of a clear spatial and modal component in the mental representations of linguistic items such as verbs. Based on previous normative tests for a set of 40 action and state Spanish verbs (Macedo et. al., 2016 and Gómez, 2017), such as that done by Richardson et. al. (2003) and Moreno and De Vega (2006), the objective of this study was to evaluate the automatic activation of the image-schemes previously tested of a specific sub-set of action and state verbs.

Background: Image-schema norming studies

Figure 1
Norming study procedure



Note: the arrangement of the figures and arrows above is arbitrary and is not intended to suggest that you have to use all of them.

Materials, participants and instruments

40 concrete verbs (involving movement) in Spanish, present, 3rd person singular

N= 300	Age (*M*) = 25.44
Spanish native speakers	SD (*M*) = 8.96
Undergraduate students	Men=59
Age= 18-60	Woman=245

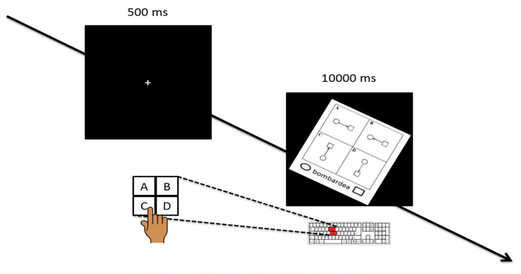
Self-administrated printed booklet with the rebug sentence and images as used by Richardson et. al. (2003)

Table 1
Norming study results of verb's scheme by task

Verb	FOT(P)	FRT(°)		Verb	FOST(P)	FRST(°)	
	M	M	SD		M	M	SD
empujar (to push)	0.83 (H)	8.57	1.58	beber (to drink)	0.57 (H)	37.85	2.14
correr (to run)	0.88 (H)	9.36	1.73	ingerir (to ingest)	0.67 (H)	39.5	2.35
perseguir (to go after)	0.82 (H)	11.10	1.82	bombardear (to bomb)	0.67 (V)	42.57	2.50
avanzar (to advance)	0.89 (H)	11.74	2.01	saltar (to jump)	0.72 (V)	45.41	2.96
atrasar (to delay)	0.65 (H)	13.43	2.03	empinar (to raise)	0.79 (V)	49.3	1.78
adelantar (to put forward)	0.81 (H)	13.56	2.01	despegar (to take off)	0.57 (V)	54.83	2.35
regresar (to return)	0.64 (H)	15.92	2.12	recordar (to remember)	0.64 (H)	55.88	3.11
retroceder (to go back)	0.73 (H)	16.11	2.11	llorar (to cry)	0.65 (V)	62.71	2.59
atraer (to attract)	0.84 (H)	18.05	2.33	escurrir (to drain)	0.73 (V)	64.28	2.42
abrazar (to hug)	0.76 (H)	18.25	2.11	trepar (to climb)	0.93 (V)	64.63	2.21
escribir (to write)	0.74 (H)	19.32	2.20	apilar (to stack)	0.75 (V)	64.92	2.71
nadar (to swim)	0.62 (H)	19.44	2.02	emerger (to emerge)	0.71 (V)	68.58	2.52
recibir (to receive)	0.84 (H)	21.16	2.44	aplanar (to flatten)	0.74 (V)	68.79	2.64
volver (to return)	0.63 (H)	21.55	2.48	izar (to run up)	0.69 (V)	71.47	1.82
leer (to read)	0.82 (H)	23.01	2.55	subir (to go up)	0.95 (V)	73.05	2.23
subrayar (to underline)	0.74 (H)	23.73	2.70	bajar (to go down)	0.99 (V)	74.66	1.83
venir (to come)	0.75 (H)	26.08	2.72	alzar (to raise)	0.89 (V)	75.17	1.95
revertir (to reverse)	0.62 (H)	27.37	2.48	caer (to fall)	0.97 (V)	76.24	1.79
dormir (to sleep)	0.52 (V)	31.98	2.73	levantar (to lift)	0.98 (V)	79.47	1.60
crecer (to grow up)	0.69 (V)	32.30	2.25	hundir (to sink)	0.95 (V)	80.75	1.61

Note: The results of the Forced choice task (FOT) are expressed in proportion (P) of responses as Horizontal (H) or Vertical (V). The results of the Free choice task (FRT) are expressed by angles (°) between an horizontal base line and drawn line(s) drawn by participants. As done by Richardson et. al. (2003), only the orientation of the arrows (Horizontal vs Vertical) but not their direction (Up vs Down vs Left vs Right) was analyzed.

Figure 2
Consistency study procedure



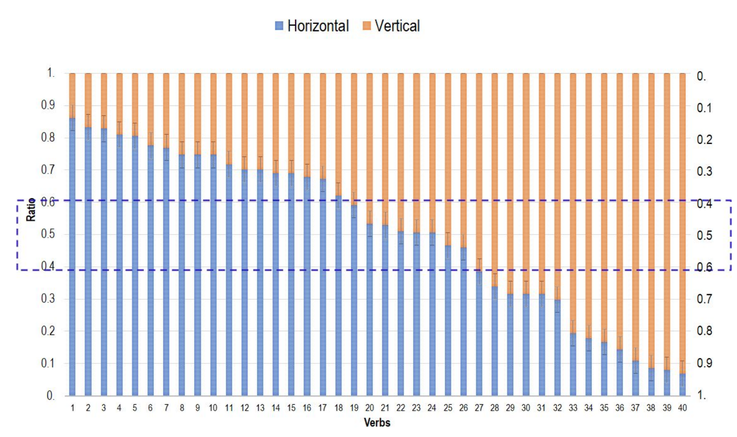
Materials, participants and instruments

The same concrete verbs of last study, we manipulate 3 variables: grammatical person (1st vs 3rd); screen setting (flatted vs stand) and page rotation (left, neutral and right)

N= 30	Age (*M*)= 24.5
Spanish native speakers	SD (*M*)= 5.7
Undergraduate students	Men= 14
Age= 18-39	Woman= 16

Psychophysics Lab: programmed in Psychopy 1.81.03 version

Table 2
Consistency of norming study results



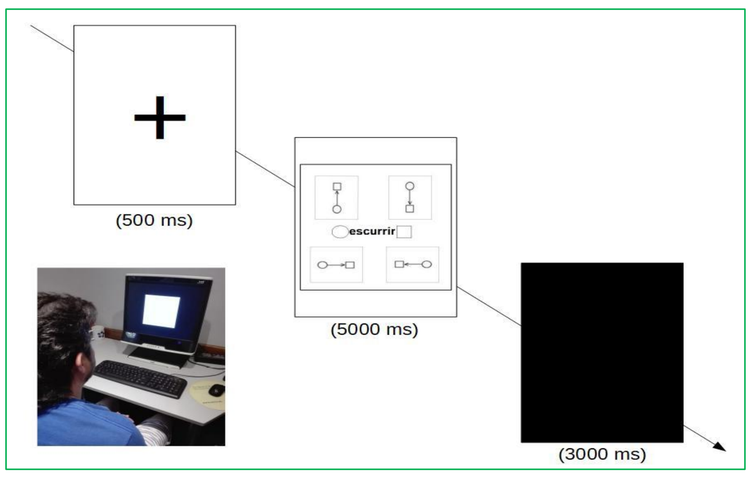
Symbology: 1: bajar: 2: levantar; 3: caer; 4: hundir; 5: subir; 6: trepar; 7: alzar; 8: empinar; 9: apilar; 10: aplanar; 11: saltar; 12; escurrir; 13: emerger; 14: crecer; 15: izar; 6: bombardear; 17: llorar 18: despegar; 19: dormir; 20: beber; 25: recordar; 27: ingerir; 21: nadar; 22: revertir; 23: volver; 24: regresar; 26: atrasar; 28: escribir; 29: retroceder; 30: subrayar; 31: venir; 32: abrazar; 33: adelantar; 34: leer; 35: perseguir; 36: empujar; 37: atraer; 38: recibir; 39: correr; 40: avanzar

Method

- In previous norming and consistency studies participants provided non-automatic categorical responses, but **How automatic are the previous image-schemes?**
- Visual word paradigm. Participants' eye movements to objects or pictures in the visual workspace are recorded via an eye tracker when the participant are claimed to read and comprehend a spoken language item (a verb into a rebug sentence) describing the concurrent visual world.
  - This paradigm is used in language comprehension task and gives the opportunity for using eye tracking measures as a kind of automatic responses in specific experimental paradigms such as this used in this study.

- Predictions: The Visit Duration and Count Visit to each Area of Interest (AOI) indicate a bias toward spatial features related to the motor and perceptual experience of the actions and states yielded by the verbs. The spatial features related to the semantics of the verbs will receive larger visits and a larger amount of them.
  - First Fixation Duration was taken as a control measures indicating that the participant strong attended to the verb at the beginning of the trails.

Figure 3
Visual word task used



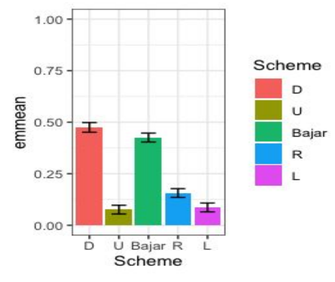
Participants, Materials and Instruments

- 31 Spanish native speakers, Age(*M)* = 25,5 years old, Age (*SD*) = 3,95, 9 men and 22 women, 29 right-handed and 2 left-handed. Undergraduated students
- 6 Spanish verbs of previous normalization studies (BAJAR, BEBER, ESCURRIR, DORMIR, RETROCEDER, SUBRAYAR) in rebug sentences with their infinitive verb form
- Psychophysics Lab: Eye tracker Tobii T-60 Hz

Results

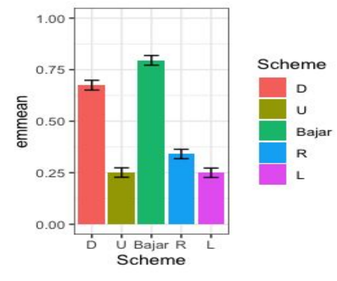
LMM. Fixed factors: Scheme (Down vs Up vs Left vs Right). Random factors: Participant. Schemes ubication in screen was counterbalanced. Signification codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. Figure's symbology: D = Down U = Up, L = Left, R = Right

Figure 5
Visit Duration for Bajar (to go down)



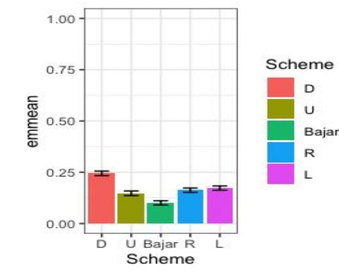
Pairwise contrast			
Down-U/L/R/Verb	*p* <.0001, *SE* = 0.06	Up-Left	*p* <.0001, *SE* = 0.06
Down-Right	*p* <.0001, *SE* = 0.06	Up-Right	*p* =.1783, *SE* = 0.06
Verb-Up	*p* <.0001, *SE* = 0.06	Verb-Right/Left	*p* <.0001, *SE* = 0.06

Figure 6
Visit Count for Bajar (to go down)



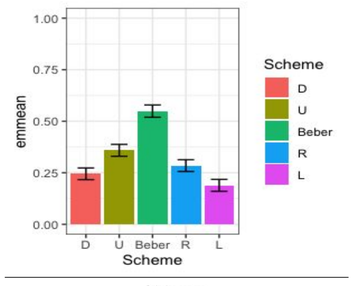
Pairwise contrast			
Down-U/R/L	*p* <.0001, *SE* = 0.06	Verb-Down	*p* = .0436, *SE* = 0.06
Verb-Up	*p* <.0001, *SE* = 0.06	Up-Right/Left	*p* ≥ .1145, *SE* = 0.06
Left-Right	*p* <.0001, *SE* = 0.06	Verb-Left/Right	*p* <.0001, *SE* = 0.06

Figure 7
First Fixation Duration for Bajar (to go down)



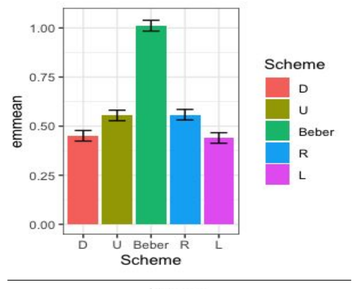
Pairwise contrast			
Verb-Down	*p* < .0001, *SE* = 0.03	Verb-Up	*p* = .1116, *SE* = 0.03
Verb-Right	*p* = .0273, *SE* = 0.03	Left-Down/Verb	*p* ≤ .0123, *SE* = 0.03
Down-Up/Right	*p* ≤ .0044, *SE* = 0.03	Left-Right/Up	*p* ≥ .3818, *SE* = 0.03

Figure 8
Visit Duration for Beber (to drink)



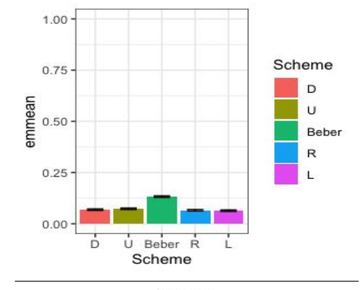
Pairwise contrast			
Down-U/L/R	*p* ≥ .1608, *SE* = 0.08	Verb-Down/Right	*p* ≤ .0017 *SE* = 0.08
Up-Right	*p* = .3608, *SE* = 0.08	Verb-Up	*p* = .0235 *SE* = 0.08
Left-Up/Verb	*p* ≤ . 0390, *SE* = 0.08	Left-Right	*p* = .2382, *SE* = 0.08

Figure 9
Visit Count for Beber (to drink)



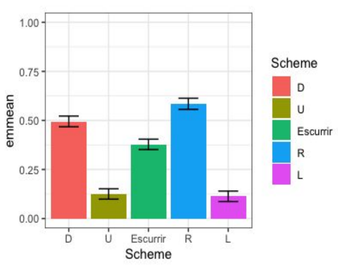
Pairwise contrast			
Down-U/L/R	*p* ≥ .0776, *SE* = 0.06	Verb-Down	*p* < .0001, *SE* = 0.06
Up-Left/Right	*p* ≥ .0601, *SE* = 0.06	Verb-Up	*p* < .0001, *SE* = 0.06
Left-Right	*p* = .0521, *SE* = 0.06	Verb-Left/Right	*p* <.0001, *SE* = 0.06

Figure 10
First Fixation Duration for Beber (to drink)



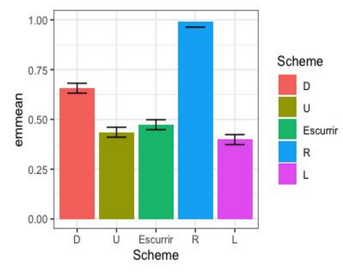
Pairwise contrast			
Verb-Down/Up	*p* < .0001, *SE* = 0.008	Verb-Right/Left	*p* < .0001, *SE* = 0.008
Down-Up	*p* = .6179, *SE* = 0.008	Down-Right/Left	*p* ≥ .5633, *SE* = 0.008
Left-Right	*p* = .8151, *SE* = 0.008	Up-Left/Right	*p* ≥ .2868, *SE* = 0.008

Figure 11
Visit Duration for Escurrir (to drain)



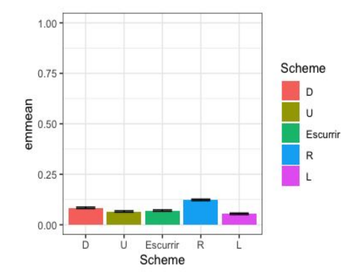
Pairwise contrast			
Down-Up/Left	*p* <.0001, *SE* = 0.08	Down-Right/Verb	*p* ≥ .1260, *SE* = 0.08
Up-Right	*p* <.0001, *SE* = 0.07	Right-Left	*p* <.0001, *SE* = 0.08
Verb-U/L/R	*p* ≤ .0085, *SE* = 0.07	Up-Left	*p* =.8756, *SE* = 0.08

Figure 12
Visit Count for Escurrir (to drain)



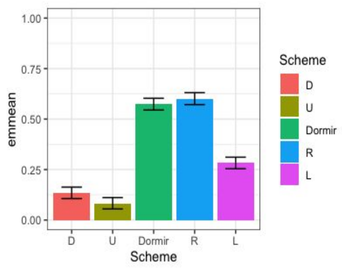
Pairwise contrast			
Down-U/L/R	*p* <.0001, *SE* = 0.05	Verb-Down	*p* = .0005, *SE* = 0.05
Up-Right	*p* <.0001, *SE* = 0.05	Up-Left	*p* = .4661, *SE* = 0.05
Verb-Up/Left	*p* ≥ .1482, *SE* = 0.05	Right-Left/Verb	*p* <.0001, *SE* = 0.05

Figure 13
First Fixation Duration for Escurrir (to drain)



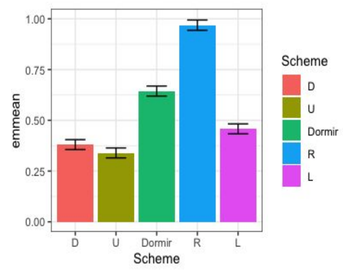
Pairwise contrast			
Verb-Down/Up	*p* ≥ .0879, *SE* = 0.008	Right-Verb/U/D/L	*p* < .0001, *SE* = 0.008
Down-Up	*p* = .0235, *SE* = 0.008	Verb-Left	*p* = .0421, *SE* = 0.008
Left-Right	*p* < .0001, *SE* = 0.008	Down-Left/Right	*p* < .0003, *SE* = 0.008

Figure 14
Visit Duration for Dormir (to sleep)



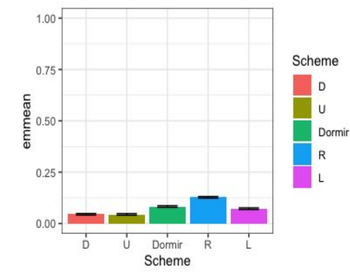
Pairwise contrast			
Down-Up	*p* = ,5190, *SE* = 0.08	Right/Left	*p* =.0002, *SE* = 0.08
Down-Right/Left	*p* ≥.0001, *SE* = 0.008	Up-Right/Left	*p* ≥.0001, *SE* = 0.008
Down/Up-Verb	*p* <.0001, *SE* = 0.008	Verb-Right/Left	*p* ≥.0005, *SE* = 0.008

Figure 15
Visit Count for Dormir (to sleep)



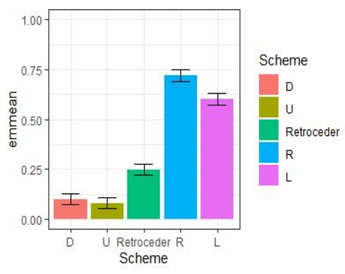
Pairwise contrast			
Down-Up/Left	*p* ≥.4504, *SE* = 0.05	Down-Right	*p* <.0001, *SE* = 0.05
Up-Left/Right	*p* ≥.0001, *SE* = 0.05	Right-Left	*p* <.0001, *SE* = 0.05
Verb-Right/Left	*p* ≥.0001, *SE* = 0.05	Verb-Up/Down	*p* <.0001, *SE* = 0.05

Figure 16
First Fixation Duration for Dormir (to sleep)



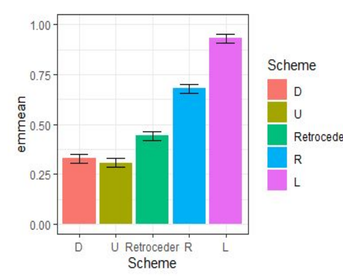
Pairwise contrast			
Verb-R/U/D	*p* ≤.0001, *SE* = 0.009	Verb-Left	*p* = .2717, *SE* = 0.009
Down-Up	*p* = .9555, *SE* = 0.009	Down-Right/Left	*p* ≥.0001, *SE* = 0.009
Up-Right/Left	*p* ≥.0001, *SE* = 0.009	Right-Left	*p* ≤.0001, *SE* = 0.009

Figure 17
Visit Duration for Retroceder (to go back)



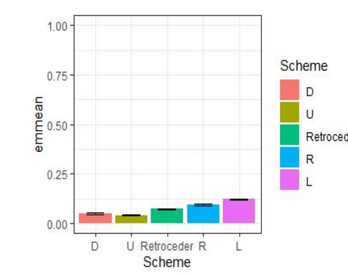
Pairwise contrast			
Left-Right	*p* = .1538, *SE* = 0.08	Down-Right/Left	*p* <.0001, *SE* = 0.08
Down-Right/Left	*p* <.0001, *SE* = 0.08	Verb-Left-Right	*p* <.0001, *SE* = 0.06
Down-Up/Verb	*p* ≥ .0588, *SE* = 0.07	Verb-Up	*p* = .00326, *SE* = 0.07

Figure 18
Visit Count for Retroceder (to go back)



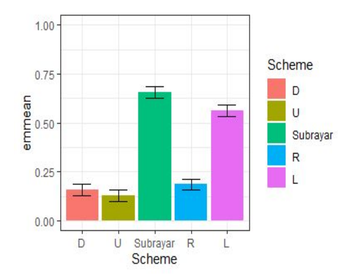
Pairwise contrast			
Left-Right	*p* <.0001, *SE* = 0.05	Down-Right/Left	*p* <.0001, *SE* = 0.05
Down-Up/Verb	*p* ≥ .0211, *SE* = 0.05	Up-Right/Left	*p* <.0001, *SE* = 0.05
Verb-Right/Left	*p* <.0001, *SE* = 0.05	Verb-Up	*p* = .0065, *SE* = 0.05

Figure 19
First Fixation Duration for Retroceder (to go back)



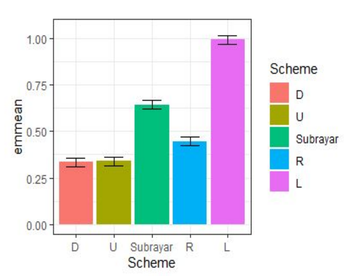
Pairwise contrast			
Verb-Left	*p* <.0001, *SE* = 0.07	Verb-Right	*p* = .0044, *SE* = 0.07
Verb-Down/Up	*p* ≥ .0001, *SE* = 0.07	Right-Left	*p* =.0003, *SE* = 0.07
Down-L/R/U	*p* ≥.0001, *SE* = 0.07	Up-Left/Right	*p* <.0001, *SE* = 0.07

Figure 20
Visit Duration for Subrayar (to underline)



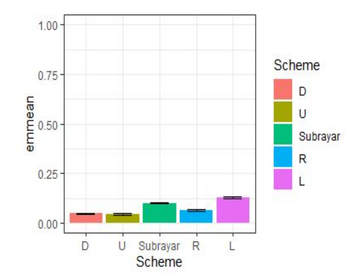
Pairwise contrast			
Right-Left	*p* <.0001, *SE* = 0.08	Down-Left	*p* <.0001, *SE* = 0.08
Down-Up/Right	*p* ≥ .7206, *SE* = 0.08	Up-Right/Left	*p* ≥.0001, *SE* = 0.08
Verb-Right/Left	*p* ≥.0001, *SE* = 0.08	Up/Down-Verb	*p* ≥.0001, *SE* = 0.08

Figure 21
Visit Count for Subrayar (to underline)



Pairwise contrast			
Down-Up/Right	*p* ≥ .0279, *SE* = 0.05	Up-Right	*p* = .0359, *SE* = 0.06
Down-Left	*p* <.0001, *SE* = 0.05	Up/Left	*p* <.0001, *SE* = 0.05
Right/Left	*p* <.0001, *SE* = 0.05	D/U/L/R-Verb	*p* ≥.0001, *SE* = 0.05

Figure 22
First Fixation Duration for Subrayar (to underline)



Pairwise contrast			
Verb-Left/Right	*p* ≥ .0001, *SE* = 0.01	Down/Up-Verb	*p* < .0001, *SE* = 0.01
Down-Up/Right	*p* ≥ 0.0773, SE = 0.01	Down/Up- Left	*p* < .0001, *SE* = 0.01
Up-Right	*p* = .0331, *SE* = 0.01	Right-Left	*p* <.0001, *SE* = 0.01

Discussion

- **Confirmed prediction: Automatic eye-tracking bias towards some spatial characteristics related to motor and perceptual experience of actions and states produced by verbs.**
- **According to our predictions, that bias was evidenced as significant more (Visit Count) and longer visits (Visit Duration) to one of more levels (left, right, up or down) of the forced choice task.**
- **The experimental paradigm used (Visual Word Paradigm) allows to collect the orientation and direction of the actions expressed by a subset of six verbs in an automatic response paradigm with eye-tracking measures.**
- **The eye-tracking measurements had good sensitivity to collect the previous spatial bias as evidences of some image schemes.**
- **The forced modality of the task was more suitable for testing schemes with a predominant linear component (e.g., BAJAR) than those with multiple components (e.g., BEBER).**
- **Although our task collected some features of the image scheme, it is not reasonable to think that those are sufficiently defined with the features collected by our paradigm.**
- **It is needed a paradigm that can collect more imaginary features and that give elements to answer how many features can be considered sufficient for an adequate, full, description of the schemes.**
- **We used First Fixation Duration (FFD) as a control measures with the expectation that the participant strong attended to the verb at the beginning of the trail. The results neither give clear support to this expectation nor a clear cut pattern between the verbs.**
- **However, the verbs with the most unidimensional schema such as BAJAR, RETROCEDER or SUBRAYAR seem to demand a larger visual attention since the first fixation.**
- **In an overview, the existence of some spatial features (orientation and direction), suggested as modal components of image schemes, was confirmed as an automatic component of some motor concrete verbs.**

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UNIVERSIDAD DE LA REPÚBLICA URUGUAY
CSIC COMISIÓN SECTORIAL DE INVESTIGACIÓN CIENTÍFICA

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