Grounding action verbs in arm-related actions

In this work we combine linguistic knowledge from classification theories (FrameNet, Levin, 1993; Antonopoulou, 1987) with sensorimotor data obtained experimentally from 16 participants, in order to better specify the minimum conceptual meaning of Modern Greek (M.G.M.V.) and American English motion verbs (A.E.M.V.).

Contextualized within the broader interests of the Artificial Intelligence field are questions related to the translation of experiences from the physical sensory world to symbols and language, otherwise known as the symbol grounding problem (Steels, 2002). We aim to perceptually ground abstract linguistic notions such as path, directionality, instrumentality, goal, purpose and lexical aspect (Talmy, 2000) based on concrete mathematical and physical terms, which share similar names but are conceptually distinct (e.g., path, goal). The resulting knowledge would benefit learning procedures both for robots, such as robust machine learning algorithms, and people with impairments, as the cases described at Kemmerer (2006).

We draw from the extensive prior work related to Cognitive Linguistics (Talmy, 2000), Mirror Neurons and their impact on language (Kemmerer, 2006), and Computer Vision (Santello, 1998). Here, we focus on the linguistically specified properties of M.G.M.V. and A.E.M.V. and on the detailed sensor data, which are analyzed to identify latent factors representing stable patterns across the many dimensions of low-level data. These factors appear as discrete sets (*synergies*) of joint angles and orientations associated with each action.

In *self-citation* ( ), the synergies of the captured average actions/verbs formed two main groups: leg- and arm-related groups. This result is consistent with the detailed linguistics classes and Wermter's neurological findings (2005). At present, we select the arm-related actions, *lift* and *turn* among others, analyze them, plot synergies and physical properties for each participant and language group separately, in order to provide a summary table for each action-verb (Table 1). Since data of this type are better related to the nature of image schemas rather than other symbolic systems, e.g., language (Lakoff & Johnson, 1999), the table properties can easily fit in an embodied framework, such as the SPG and Motion schemas of Embodied Construction Grammar (Feldman *et al.*, 2009) (Figure1).

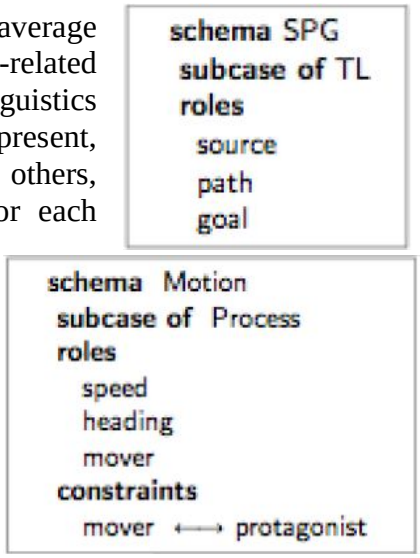
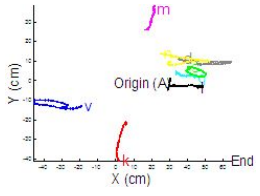
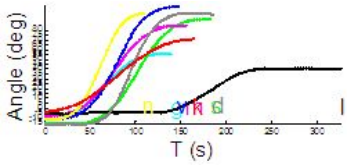
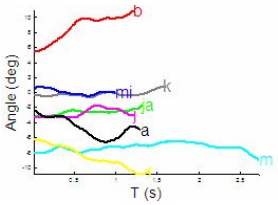


Figure 1. The SPG and Motion schemas

Table 2. *lift/sikono* verb (due to limitation of space we present only one language's plots)

Linguistic properties		**Description**	**Instrumentality**	**Plot**
Path		small curve	Greek→hips x + shoulders x American→shoulders x	
Direction	**Back-forth**	forth (imperceptibly)		
	Right-left	-	-	

	Up-down	up	Both → shoulders z wrists z	
Lexical aspect		instant	-	
Gaze		precedes wrist-object (0.2 sec)	Both→ head z	

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