A conceptual analysis of verbs of *pushing* and *pulling*

Within the theory of *Conceptual Spaces* (Gärdenfors, 2000), concepts are analysed as regions in multi-dimensional spaces which are derived from (fine-grained) semantic dimensions. Such dimensions are assumed to be derivable to a large extent from perception (Gärdenfors 2000, 2007; Gärdenfors & Warglien 2012). Previous research has provided profound evidence for a geometrical organization of concepts in the (direct) sensory domain, such as colour (Berlin et al., 1969), olfaction (Majid et al., 2018), static spatial relations (Levinson et al., 2006), and even prototypical instances of motion events (Giese et al. 2008, Malt et al. 2014). However, less progress has been made in the conceptual space of actions and events involving both an agent and a patient such as events of *pushing* and *pulling*.

Recent studies have used simple 2D videos to elicit naming of basic pushing and pulling events focusing on the difference between verb- and satellite-framed languages (e.g. Hickmann et al., 2018; Montero-Melis, 2021). However, these studies do not allow a fine-grained identification of the relevant semantic properties needed to develop a semantic analysis of such verbs, which must be considered an important desidaratum in cognitive linguistics.

Based on the assumption that "the fundamental cognitive representation of an action consists of the pattern of forces that generates it" (Gärdenfors and Warglien 2012: 498; cf. also Talmy 1988), the present study presents the results of a free production experiment that aimed at assessing in more detail which semantic dimensions make out the domain of *pushing* and *pulling* as a fundamental domain of physical interaction between agents and patients. Pinpointing conceptual boundaries requires investigating *peripheral event instances*, which leads to large number of combinatorial possibilities to be tested in a systematic explaration of conceptual spaces. We approached this problem by presenting participants with short 3D video clips in which a computer-animated agent moved a barrel a short distance, allowing for fine-grained adjustments of potentially impactful properties. Among the numerous dimensions possibly involved, we manipulated four: i) the angle of contact between agent and object, ii) the strength of force used by the agent, iii) the duration of contact, and iv) the agent's orientation (facing the object or the direction of movement). In our study, the main research goal was to determine the predictors that trigger the production of different verbs and to classify them in semantic verb clusters. The role of modifiers of various types is not discussed in this presentation.

Methods. The 3D videos involved a human-like agent causing the movement of a barrel (see Fig. 1). The 3 second videos were created using a state-of-the-art physics engine according to a $7\times2\times2\times2$ fully within-design with the factors **Angle between human and barrel** (0, 45, 90, 105, 120, 135, 180), **Barrel movement** (*continuous* vs. *instantaneous*), **Facing direction** (*towards barrel* vs. *forward in direction of movement*) and **Force** (*heavy* vs. *light*). This resulted in a total of 52 trials (at 0 degrees, facing direction cannot be differentiated). We recruited 81 native speakers of German (45 female; mean age: 24.5) via Prolific, who were told that they should provide descriptions rich enough to categorize the videos for a second group of participants. After each video, participants were prompted to answer the question *What does the person do with the barrel?* (in German), for which the following prompt was provided: *The person ….*

Data. We gathered a corpus of 4212 descriptions (word length range: 3–70, mean 8.7). We annotated the main matrix verbs that expressed movement of the barrel (in addition to a number of other properties not yet finalized). We found 95 different matrix verb constructions with 9 matrix verbs that have a frequency $> 0.5\%$: *ziehen* 'pull' (1635), *schieben* 'push' (1156), *drücken* 'push' (195), *schubsen* 'shove' (195), *stoßen* 'poke' (176), *gehen* 'walk' (173), *bewegen (reflexive)* 'move oneself' (102), *bewegen* 'move' (71), *laufen* 'walk' (29). **Results.** K–means clustering ($k = 3$) for