Kinematics and literacy; towards an intelligent tutoring system

In this presentation, we attempt to combine motion captured data with linguistic notions in a game-like intelligent tutoring system, in order to help elementary school students to (a) better differentiate literal from metaphorical uses of motion verbs, based on embodied information. In addition to the thematic goal, we intend to (b) improve young students' attention and spatiotemporal memory, by presenting sensorimotor data experimentally collected from thirty two participants in our motion capturing labs. Furthermore, we examine (c) the accomplishment of the game's goals and compare it to curriculum's approach.

Concerning the use of kinematics, several disciplines dictate the necessity of investigating whether sensorimotor features shape the mechanism of semantic structure or not. Psychology claims that the first data perceived and processed in infancy are of sensorimotor nature. For this reason Piaget (1952) named the first developmental period as the sensorimotor stage of cognitive development. Similarly, neurologists (Rizzolati, Fadiga, Gallese & Fogassi, 1996) allege that mirror neurons incorporate action in a sensorimotor gestalt. Due to these data, human brain forms concepts and expresses them through language. Linguists, such as Lakoff and Johnson (2003) embrace the neurological findings while they name this neurological sensorimotor format as *image schemas*. These schemata seem to more objectively represent the surrounding natural world, while their verbal description is a different symbolic system and it lacks full metacognitive description of the nature of image schemas. Based on this assumption, we understand that, even though children already possess action image schemas that correspond to motion verbs, e.g. turn around, they are not fully able to recognize the prototypical action depicted by verbs. Moreover, they have not fully associated the action-verb pair with literal concept and through literacy to discern metaphorical meaning. Children still use intuitive means to distinguish literacy from metaphora, which are still unstable and cause mistakes. Instead, if they concretely see the action and straight forward associate it with literal vs. metaphorical use, they realize it as fundamental metacognitive technique that can be used afterwards without the stimulus but by mental recall.

Sensorimotor collection:
Initially, we collected sensorimotor data from native speakers of three languages (American English, German and Greek), in the context of a broader experiment related to grounding language to motion, whose subcase is the current game. We captured our motion data with an XsensMVN suit, which contains 16 embedded inertial motion detectors. Each sensor consists of 3D gyroscopes, accelerometers and magnetometers and we analyzed the sensorimotor data in such a way to recognize latent variables in low level data, which disclose stable patterns in many dimensions. These latent variables appear as distinct groups of synergies and their orientations -as to the axes associated with each joint separately.
As soon as we experimentally found the counterpart in different languages, we uttered verbs, such as *walk, trigger, lift, turn, etc,* to participants, who performed the described action. To normalize the

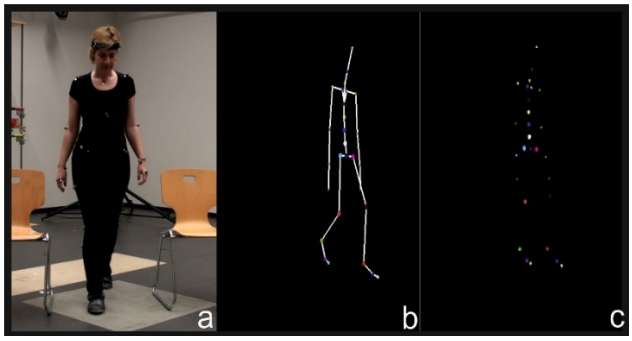

Figure 1. Video, avatar with "bones" and "point light" avatar

process, participants were encouraged to begin moving from a particular angle in a square, for those cases considered it was possible. Basic limitation of the experiment was participants to use only their body and as little as possible items that were considered as strictly necessary for the performance of the verbal concept. Although the majority of actions could be implemented only with the body, there were available objects in the laboratory, such as a plastic step, an inclined plane, one or more tennis balls, a table, a book, a cylinder and a chair. Once again, for normalization purposes, the same objects were available for all experiments, but their use was on the discretion of participants.

An intelligent tutoring system enriched with serious game's parameters:
We suggest an architecture that combines intelligent tutoring systems (ITS) and serious gaming principles with pedagogical objectives. Moreover, we attempt to provide assistance for self-correction, in order to increase productive learning behaviors, supporting both cognitive and metacognitive process.

Evaluation study of the systems learning effectiveness in elementary school students:
Sixty nine elementary school students were randomly divided in two experimental groups (game and traditional) and one control group, which did not undergo any intervention. All groups were tested in pre and posttests. Even though, the diagnostic pretests present a uniform picture, two way analysis of variance suggests that the experimental groups showed progress in posttests, with game group showing remarkable progress especially in the verbs/actions presented during the intervention. Moreover, in the game condition the participants needed gradually shorter period of time to identify the avatar's actions. This finding was considered as a first indication of attentional and spatiotemporal memory's improvement, while the game's assistance features cultivated students' metacognitive perception.

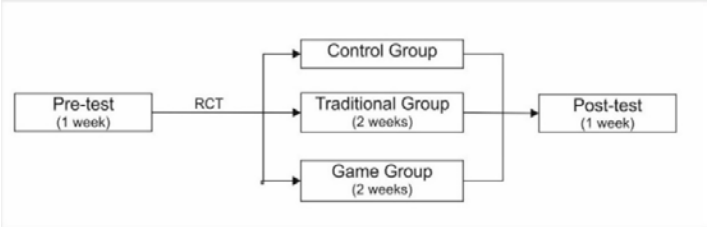

Figure 2.Schematic evaluation-study design

Brief conclusion:
Overall, a software that incorporates sensorimotor data and linguistic knowledge elicits language related learning achievements and at the same time boosts spatiotemporal memory, attention and through hint providing cultivates better metacognitive mechanisms, which can help elementary school students to overcome cognitive limitations of their age urging them to abstract reasoning.
Traditional teaching approaches, such as the use of textbooks, homework, and blackboard, have been extensively tested in the past and enriched with diverse intervention tools. In general texts can provide necessary stylistic information that will elevate cognitive concepts and their linguistic expressions. Thus, our data and analysis show that a game-like virtual reality environment could benefit traditional interventions, especially for elementary school students. Furthermore, our study introduces the use of kinetic data by deploying embodiment for the needs of language learning. Future studies could develop sensorimotor information for L2 acquisition or for home based consolidation of knowledge.