

# The Anticipatory Function of External Representations

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This paper represents a preliminary study of the Anticipatory Function of external representations (ERs), that is, of the ability of external representations to fulfill the function of fostering knowledge acquisition. It is structured around a case study of a subject (R) who talked aloud and drew diagrams as she learned from a physics text. The text described a ball falling in a curved path after being pushed off a table with a uniform horizontal velocity. The verbal and diagrammatic protocol was selected at random from a sample of fifteen subjects. The present portion of R's protocol was also randomly chosen among a set of five possible sections and was coded independently by two researchers. The criteria used for constraining the interpretation of the protocol included: R's gestures and activities during the episode, R's verbalizations and diagrams immediately preceding and following the episode, and a post-test interview.

R started out with a uni-dimensional conception of motion and figured out the two-dimensional meaning of a curved path. Her diagram helped her reach a two-dimensional conception in three phases: "Dissociative," "Generative," and "Transfigurative." The "Dissociative" phase allowed the encoding of appropriate external features (two arrows) of an internal representation still in need of being conceived (2D-motion). The "Generative" phase resulted in the addition of both external and internal knowledge to R's knowledge base via the use of knowledge elements taken from vector addition, which resulted in a diagonal path as a possible trajectory. The "Transfigurative" phase allowed R to use external elements from the preceding phase (the configuration from vector addition) in the context of a new internal and external representations (the successive flashes of the ball as it falls). Major diagrammatic properties involved in each phase are: semantic and syntactic density (Goodman, 1968), adjacency (Larkin & Simon, 1987), and familiarity with the transcription of certain knowledge elements (e.g., vertical and horizontal qualities).

Even though this study is preliminary and based on a single case study, certain observations can be made that have consequences for current research on the role of ERs in knowledge acquisition. First, a key aspect of the case study lies in the fact that R's diagrams supported numerous degrees

of freedom for interpretation through their properties of semantic and syntactic density. This meant flexibility to foster the emergence of new knowledge, but also a need for constraints from other external sources (the sentences) to channel processing in an appropriate direction. This issue of the role of semantic and syntactic density and the trade-off between flexibility and the need for cognitive constraints is a key problem in understanding how ERs can be useful for novices to achieve learning. Importantly, the case study suggests that answers to this trade-off problem will not be found by focusing on diagrammatic properties in isolation, as it is often done in current research on ERs, but by an integrative analysis of how diagrammatic properties act in concert and interact with internal aspects of the situation (e.g., how they fit a learner's internal model). This case study extends claims made elsewhere regarding both the use of functional analysis (e.g., Cheng, 1996) and the importance of the connections between the internal and the external realms (e.g., Scaife & Rogers, 1996; Stenning & Oberlander, 1995).

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