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Transfer of learning between 2D and 3D sources during infancy: Informing theory and practice

Rachel Barr

Department of Psychology, Georgetown University, Washington, DC 20057, United States

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ABSTRACT

The ability to transfer learning across contexts is an adaptive skill that develops rapidly during early childhood. Learning from television is a specific instance of transfer of learning between a two-dimensional (2D) representation and a three-dimensional (3D) object. Understanding the conditions under which young children might accomplish this particular kind of transfer is important because by 2 years of age 90% of US children are viewing television on a daily basis. Recent research shows that children can imitate actions presented on television using the corresponding real-world objects, but this same research also shows that children learn less from television than they do from live demonstrations until they are at least 3 years old; termed the *video deficit effect*. At present, there is no coherent theory to account for the video deficit effect; how learning is disrupted by this change in context is poorly understood. The aims of the present review are: (1) to review the conditions under which children transfer learning between 2D images and 3D objects during early childhood and (2) to integrate developmental theories of memory processing into the transfer of learning from media literature using Hayne's (2004) developmental representational flexibility account. The review will conclude that studies on the transfer of learning between 2D and 3D sources have important theoretical implications for general developmental theories of cognitive development, and in particular the development of a flexible representational system, as well as policy implications for early education regarding the potential use and limitations of media as effective teaching tools during early childhood.

E-mail address: rfb5@georgetown.edu

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Introduction

The notion of transfer of learning across contexts has been central to memory theorists since the time of Thorndike (1932) and many recent memory theories have been developed that have transfer of learning at their core. Theorists generally assume that a memory is a hypothetical collection of attributes that represent what the subject noticed at the time of original encoding (Estes, 1973; Estes, 1976; Roediger, 2000; Spear, 1978; Tulving, 1983; Underwood, 1969). The encoding specificity hypothesis states that a memory will be retrieved only if an individual encounters a cue with attributes that match those represented in the memory at the time of original encoding (Tulving, 1983). The ability to retrieve memories despite changes in proximal or distal cues, allowing learning to be generalized to novel situations has been referred to as 'representational flexibility' (Eichenbaum, 1997).

Historically, researchers have suggested that representational systems emerge relatively late in infancy (e.g., Baldwin, 1894/1915; Piaget, 1962). More recently, Hayne (2004) has argued that there are marked developmental changes in representational flexibility that occur even into early childhood. That is, early in development, successful memory performance is dependent on the perception of a close match between the cues at the time of encoding and the cues at retrieval; even minor mismatch at testing can disrupt performance. However, memory performance becomes more flexible across development. Older participants show an increased ability to tolerate differences between conditions at encoding and retrieval and can use novel cues to retrieve a target memory. Developmental studies of transfer of learning across physical contexts and objects have shown age-related changes in generalization using operant conditioning procedures (Hartshorn et al., 1998; Hayne & Findlay, 1995) and with toddlers using the imitation paradigm (Barnat, Klein, & Meltzoff, 1996; Hanna & Meltzoff, 1993; Hayne, Barr, & Herbert, 2003a; Hayne, Boniface, & Barr, 2000; Hayne, MacDonald, & Barr, 1997; Herbert & Hayne, 2000; Klein & Meltzoff, 1999). Hayne argues that the gradual developmental change occurs because over time infants need to encode information in a variety of contexts and take advantage of a wide range of retrieval cues. The representational flexibility account posits the existence of an active developmental process whereby performance is dependent upon age, task, and experience.

The representational flexibility account highlights an additional cognitive difficulty presented by the need to equate between 2D sources, including television, books, touch screens and computers, and 3D objects. According to this account, the infant must cognitively match a 2D symbol present at encoding to the corresponding 3D referent present at testing. Successful transfer of learning in an imitation task for example, involves the formation of both an object and an action representation that can be retained over a delay. That is, infants must form an internal mental representation of the target actions at the time of demonstration, as well as, encode specific perceptual features of the objects, context, and model used during the demonstration (Bandura, 1986; Estes, 1973; Estes, 1976; Meltzoff, 1988c; Tulving, 1983). At the time of the test, infants must match perceptual attributes of the 3D test object that is presented to stored attributes of the memory representation of the original 2D video display. Ultimately success on 2D–3D transfer tasks would depend on the operation of a flexible capacity to recognize and act on the stimulus regardless of its dimension at the time of encoding. Based on Hayne's hypothesis, learning from 2D sources would be more challenging than learning from face-to-face interactions because there are fewer retrieval cues at the time of the test that specifically match the original encoding conditions.

Transfer of learning across content and context is at the core of educational policy; it enables the development of abstract thinking, and in particular the development of a flexible representational system (Barnett & Ceci, 2002; Hayne, 2004). Learning from books, television, touch screens and computers can be considered a specific form of transfer of learning from a 2D representation to a corresponding 3D response. Studies that examine 2D–3D transfer of learning provide us with important practical, educational information about learning across these different media platforms. At the same time, these findings will also provide us with new theoretical information, garnered from highly controlled manipulations, about the developmental course of transfer of learning (Durkin & Blades, 2009). Taking Barnett and Ceci's framework into consideration, studies of transfer of learning from 2D sources allows for specific manipulation of modality (from 2D to 3D and vice versa), physical context (different experimenter, different room), temporal context (immediate v. delay), tasks difficulty (simple v. complex tasks), memory demands (practice, repetition, delay), and perceptual and linguistic