ABSTRACT. Modern neuroscientific research has substantially enhanced our understanding of the human brain. However, many challenges remain in developing a strong, brain-based theory of human learning, especially in complex environments such as educational settings. Some of the current issues and challenges in our progress toward developing comprehensive neuroscientific-based theories of human learning, particularly in the academic disciplines, are reviewed, beginning with a brief summary of the history of publications in science learning. This is followed by an analysis of some of the large-scale issues and conceptual problems that we currently face in developing a strong, middle-ground “neuroeducational theory” relevant to learning, especially in rather abstract disciplines such as mathematics and science. Finally, some perspectives on possible future strategies and challenges in reaching the goal of a neuroeducational theory are presented.

KEY WORDS: brain imaging and analysis, brain science and science education, cognitive learning theory, neurocognitive models, neuroeducational theory, neuropsychology and learning, science curriculum improvement, science learning theory

INTRODUCTION

The rapid expansion of new learning media beginning in the mid-twentieth century has substantially enhanced content richness and individualized opportunities for learning, especially in mathematics, sciences, and related disciplines. For example, the breadth of information and multi-modal processing (including affective, cognitive, and psychomotor interactions) afforded by modern digital learning technologies have opened new vistas of enhancing student learning. However, these advances also have raised new challenges in understanding more fully how learners process these potentially rich information resources. Increasing evidence from basic neurosciences, developmental neuropsychology, and investigation of human brain functions at varying ages and across grade levels may provide stronger theoretical foundations for developing valid and practical prescriptions for modern learning media in mathematics and science curricula, including
across-grade-level progressions that enhance the transfer of knowledge and skills from one grade to the next (e.g. Corcoran, Mosher & Rogat, 2009; National Research Council, 2011; Achieve, 2013; Duncan and Rivet, 2013). Brain sciences, though making marked progress in the last several decades, face interesting challenges in reaching a level of scientific maturity that will allow us to synthesize research from the neurosciences and human learning sciences into strong theories to guide the design and delivery of optimal learning experiences, especially in conceptually abstract disciplines such as mathematics and sciences. The opportunity for merging neurosciences with modern digital technology design theory and best delivery practices is clearly significant and likely to be highly productive in advancing the efficacy of these learning environments. The emerging field of neuroscience based digital learning theory, as with science education neurocognitive theory, is only beginning to develop. Thus far, there has not been an apparent blossoming of publications in this seminal interdisciplinary field, although some highly visible commercial applications based on cognitive and neuroscientific research have been developed and widely publicized (e.g. “Fast ForWord®” distributed by Scientific Learning, Oakland, CA) as reviewed by Doidge (2008).

PURPOSE

The purpose of this paper is threefold: (1) to provide a historical summary of some of the published research in the area of neuroscience and science education, (2) to establish a context for some of the current challenges in creating a middle-ground theory of what I will call “neuroeducational” that spans neurosciences and the socio-emotional-cognitive sciences in an educationally relevant context, and (3) to review some current published perspectives on these challenges and our prospects for the future in meeting them. Some implications for digital learning media in the sciences and cognate disciplines are also addressed, where possible.

HISTORICAL PERSPECTIVE

Historically, there has been a relatively recent (late twentieth century) and sporadically consistent interest among some science education scholars to search for a strong theory that merges neuroscience with science learning theory. These endeavors represent efforts to integrate learning theory with