Scientific Bases For

# The Eddy's Number Party!™ Game

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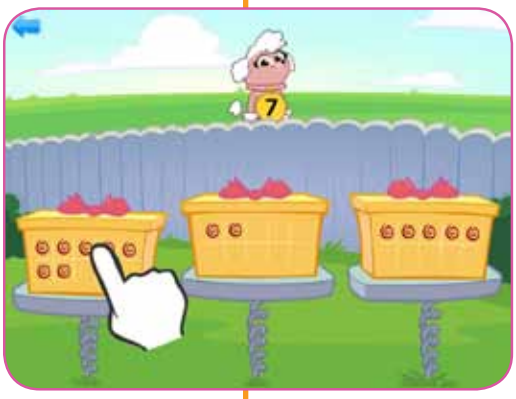
## Understanding Numbers: Cardinality and Ordinality

Humans, and many other animals, are born with a general number sense. This general number sense includes a basic understanding of cardinality—the absolute size of each number. For example, an infant can recognize the commonality between three large blue circles, three small red squares, and three medium-size green triangles. The general number sense also includes a basic understanding of ordinality—the relational properties of each number. For example, infants can distinguish between a larger number of dots and a smaller number—whether that is two dots over one, three dots over two, or six dots over four—even when the smaller number of dots covers a larger area (Van Loosbroek & Smitsman, 1990; Starkey, Spelke, & Gelman, 1990). Infants also can match numbers across modalities; for example, connecting three dots to three tones (Spelke, 1976).




## What Young Children Need to Learn About Numbers

While children have a general number sense, some things that are obvious to adults are not so obvious to children. For example, to adults, it is obvious that you should give more objects to someone who asks for six than to someone who asks for four. Many preschoolers, however, do not find this obvious at all – even preschoolers who can count from one to ten flawlessly (Le Corre & Carey, 2007; 2008). Likewise, adults see it as obvious that seven must be larger than five, because seven comes after five when counting from one to ten. Yet many children who can count from one to ten have no idea which of any two numbers in that range is larger (Okamoto & Case, 1996; Ramani & Siegler, 2008).

To overcome these limitations on their number knowledge, children must learn to connect groups of objects or events to symbolically expressed numbers. For instance, a child must learn to connect 12 dots with the spoken number name "twelve" and to connect seven tolls of a bell with the written numeral "7." Making these connections is one of the most important mathematical competencies children are asked to acquire during the preschool and early elementary school years. One of the most common learning tasks given young children is to determine the number of objects in a set, either by visual recognition (subitizing) or by counting (Gelman & Gallistel, 1978; Trick & Pylyshyn, 2003). Other important challenges during the early school years include acquiring skills relevant to cardinality, such as recognizing and generating the number symbols that accompany sets of a particular size, and skills relevant to ordinality, such as identifying the larger of two numbers.

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Beyond learning number names and counting routines, research has shown that verbal representations of numbers are linked to spatial representations, and

that this linkage plays an important role in numerical understanding (Ansari, 2008; Hubbard, Piazza, Pinel, & Dehaene, 2005; Siegler & Ramani, 2009). At the neural level, a circuit connecting the prefrontal cortex and an area in the parietal lobe known as the horizontal intraparietal sulcus (HIPS) area has been found to be crucial for these linked representations (Nieder & Dehaene, 2009; Dehaene, Molko, Cohen, & Wilson, 2004; Hubbard & McCandliss, 2011). At the behavioral level, how precisely the verbal and spatial representations of number are linked is related to both preschool and elementary school children's arithmetic skills, and to elementary school children's overall math achievement test scores (Booth & Siegler, 2006; 2008; Geary, Hoard, Nugent, & Byrd-Craven, 2008; Geary, Hoard, Byrd-Craven, Nugent, & Numtee, 2007).

## How the Eddy's Number Party! Game Develops Number Knowledge

The Eddy's Number Party! game uses principles derived from cognitive science research to facilitate children's efforts to connect number symbols with quantities, to link verbal and spatial representations of numbers, and to better understand both the cardinal and ordinal properties of numbers. In the game, children are presented with carefully sequenced tasks, such as matching written numbers to the equivalent number of objects, counting the number of events in a series, and remembering the locations of hidden numbers and sets.

## The Role of Cognitive Skills in Learning

As important as it is for children to master numbers and other educational content, it is also important for them to strengthen the foundational cognitive skills that are necessary for academic success (Duncan, et al., 2007; Swanson, Jerman, & Zheng, 2008). These skills include selective attention, which is the ability to focus on task-relevant information (Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005), and working memory, which is the ability to keep information in mind and reorganize or manipulate it as needed to complete a task (Bunge & Wright, 2007; Crone, Wendelken, Donohue, van Leijenhorst, & Bunge, 2006). To help build these critical cognitive skills, the tasks in Eddy's Number Party! game become more challenging as the game progresses—not only in terms of number processing demands, but also in terms of attentional and working memory demands.

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## Effective Learning Activities

Learning is most effective when the activities and examples used vary in their superficial properties while illustrating the same underlying concept. For this reason, the tasks within the Eddy's Number Party! game are designed to be highly variable in their surface structure—varying in the objects that are being connected with numbers, in the objects' spatial configuration, and in the particular game contexts and goals—while continuously reinforcing the game's core concepts and skills: number sense, attentional skills, and working memory.

## Conclusion

The scientific research-based design of the game—informed by findings on general principles of learning, the specifics of numerical development, and the development of cognitive skills—promises to make the Eddy's Number Party! game an especially effective learning activity.

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## Scientific Advisors to the Eddy's Number Party! Game


**Silvia A. Bunge**, Ph.D., is an Associate Professor at the University of California, Berkeley, in the Department of Psychology and the Helen Wills Neuroscience Institute. She earned a Ph.D. in neuroscience from Stanford University, and completed post-doctoral training at the Massachusetts Institute of Technology. Dr. Bunge's lab uses behavioral and brain imaging techniques to examine how we control our thoughts and actions to make them consistent with our internal goals. She has published over 50 peer-reviewed research papers and has lectured extensively on the neuroscience of cognitive control and rule-guided behavior. Dr. Bunge has received numerous grants and honors for her research, including the Cognitive Neuroscience Society's Young Investigator Award, a John Merck Scholarship on the Biology of Developmental Disabilities, and a James S. McDonnell Scholar Award. She has also been selected as a member of the National Scientific Council on the Developing Child. Dr. Bunge is working with Scientific Learning as a scientific consultant to develop computer-based activities that help children improve their executive function skills.

**Barbara M. Calhoun, Ph.D.**, is a Senior Research Scientist at Scientific Learning Corporation, and has been with the company since 1998. She earned a Ph.D. in bioengineering with a focus on auditory neuroscience from the University of California, Berkeley and the University of California, San Francisco, with additional training in auditory neuroscience from the Johns Hopkins University. Dr. Calhoun is involved in research collaborations with educators, clinicians, and university-based researchers all over the world who are studying the effectiveness of Scientific Learning software for diverse student populations. She has published various articles within the field of neuroscience and holds several U.S. patents. Dr. Calhoun is the recipient of several awards, including the National Research Service Award and the University of California Regents' fellowship.

**Logan E. De Ley, M.A., M.S.**, is a Research Associate at Scientific Learning Corporation, and has been with the company since 2000. He earned an M.A. in experimental psychology from the University of California, Davis, and an M.S. in communicative disorders with clinical training in speech and language pathology from San Francisco State University. Mr. De Ley has worked on numerous research studies examining the effectiveness of Scientific Learning software, and has published articles, chapters, and reports on this research and related topics. He has co-authored several commercial software products and holds patents for innovations in these products.

**William M. Jenkins, Ph.D.**, is the Chief Scientific Officer of Scientific Learning Corporation, and one of the company's founders. Dr. Jenkins has been with the company since its inception in 1995, coming from a faculty position at the Keck Center for Integrative Neurosciences at the University of California, San Francisco Medical Center. Dr. Jenkins is an expert in learning-based brain plasticity, behavioral algorithms, and psychophysical methods. He earned a Ph.D. in psychobiology from Florida State University, and has authored or co-authored more than 100 publications and 13 commercial software products. He also holds 46 U.S. patents and 12 foreign patents. Dr. Jenkins was the recipient of the Year 2000 Thomas Alva Edison Patent Award and has been recognized by Discovery Magazine in its annual Awards for Technology Innovations.

**Virginia A. Mann, Ph.D.**, is a Professor at the University of California, Irvine, in the Department of Cognitive Sciences. She earned a Ph.D. in psychology from the Massachusetts Institute of Technology, and has published more than 80 research articles and chapters in the areas of phonological processing, memory, cognition, and predictors of early reading ability. Dr. Mann serves on the editorial and scientific advisory boards of the Journal of Learning Disabilities and the National Dyslexia Research Foundation, and her research has been recognized with a Fulbright Fellowship, a Yoikuin Fellowship, the Hartman Award, and an International Reading Association Award. Dr. Mann also directs two outreach programs: 'HABLA,' which helps Spanish-speaking families prepare their preschool-aged children to do well in school, and 'UCI Jumpstart,' which is part of a national system for increasing English skills through college student mentoring of preschool students. Dr. Mann is working with Scientific Learning as a scientific consultant to develop computer-based activities that help young children develop critical cognitive skills. Previously, she has worked with Scientific Learning to create a series of educational software products with a reading focus, and she holds patents for innovations in these products.

**Amanda McKerracher, M.A.**, is a doctoral student in school psychology at the University of California, Berkeley. She earned a B.Sc. in psychology from the University of Toronto, and an M.A. in child study and education from the University of Toronto's Ontario Institute for Studies in Education (OISE/UT). In

Canada, Ms. McKerracher is a certified K-6 teacher, with credentials in both special education and early childhood education. Her research interests are in the area of normal and abnormal development of mathematical abilities in young children. Ms. McKerracher is working with Scientific Learning as an intern, contributing to the development of computer-based activities that help children improve their numeracy and math skills.

**Robert S. Siegler, Ph.D.**, is the Teresa Heinz Professor of Cognitive Psychology at Carnegie Mellon University. He earned a Ph.D. in Psychology at the State University of New York at Stony Brook. Dr. Siegler's research focuses on children's thinking, particularly their mathematical and scientific thinking. Among the topics examined within his work are how representations of numbers change with age and experience, and what types of mathematical experiences are especially helpful for improving math achievement. Dr. Siegler has published more than 200 articles and chapters, written 8 books, and edited 5 others. From 2006 to 2008, he served on the National Mathematics Advisory Panel, a group asked to recommend ways of improving mathematics education in the U.S. The contribution of Dr. Siegler's research has been recognized in numerous ways. He has been awarded the American Psychological Association's Distinguished Scientific Contribution Award, elected to the National Academy of Education, awarded the Brotherton Fellowship, and invited to give keynote addresses at more than 50 conferences. Dr. Siegler is working with Scientific Learning as a scientific consultant to develop computer-based activities that help children improve their numeracy and other cognitive skills.

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## About the Eddy's Number Party!™ Game

Welcome to the party! The Eddy's Number Party! game is a kindergarten readiness iPad app that gets young children counting, matching numbers, and improving memory and attention, all while getting ready for Eddy's big surprise party! Children collect balloons, toss presents, track party hats, and earn stickers as they gather friends to bring to Eddy's party. Search "Eddy's Number Party" in the iPad app store to play.

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## About the KinderSpark™ Series

The KinderSpark series is a collection of engaging iPad games that help young children build kindergarten readiness skills and excel in learning. Our "secret sauce" is the pairing of cognitive development research with curriculum. We think of it as learning disguised as fun!