Mathematically gifted adolescents use more extensive and more bilateral areas of the fronto-parietal network than controls during executive functioning and fluid reasoning tasks

Manuel Desco a,b,c, Francisco J. Navas-Sanchez b,c,⁎, Javier Sanchez-González c,d, Santiago Reig b,c, Olalla Robles e,f, Carolina Franco e, Juan A. Guzmán-De-Villoria b,g, Pedro García-Barreno b,c,h, Celso Arango b,e

a Dept. of Bioengineering and Aerospace Engineering, University Carlos III of Madrid, Spain
b Centro de Investigación Biomédica en Red de Salud Mental (CIBERSAM), Madrid, Spain
c Centro de Referencia Estatal de Atención al Daño Cerebral (CEADAC), Madrid, Spain
d Philips Healthcare, Clinical Science, Madrid, Spain
e Centro de Investigación Biomédica en Red de Salud Mental (CIBERSAM), Madrid, Spain
f Department of Experimental Surgery and Medicine, Hospital General Universitario Gregorio Marañón, Madrid, Spain
g Department of Experimental Surgery and Medicine, Hospital General Universitario Gregorio Marañón, Madrid, Spain
h Moroccan Academy of Mathematical, Physical and Natural Sciences Madrid, Spain

Introduction

The capacity for fluid reasoning, working memory, and mental imagery is considered to be fundamental for skilled mathematical reasoning (Gray et al., 2003; Lee et al., 2006). Mathematical thinking is associated with comprehension, understanding, and using patterns, as well as with organizing and systematizing our ideas to discover the rules that govern processes involving numbers. Fluid reasoning, working memory, and mental imagery are thought to be crucial for mathematical thinking. Fluid reasoning is the ability to perceive complex relations and engage in working memory, concept formation, reasoning, and abstraction. Working memory makes it possible to retain and manipulate information from intermediate steps while solving a problem (Newman et al., 2003; Prabhakaran et al., 1997). Mental imagery is the ability to visualize mental images that are structurally similar to perceptions during reasoning in order to find new information not explicitly given in the premises; this ability makes it easier to clarify and understand data and the relationships between them. These relationships may be tangible (e.g., graphs, maps, or three-dimensional models) or mental (e.g., mental images that can be used during reasoning to find new information not explicitly given in the problem) (Knauff et al., 2002).

Results from functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) studies suggest that fluid reasoning is associated with activation of a network of frontal and parietal brain