# Chapter 7.19
# The Paleolithic Stone Age Effect?
## Gender Differences Performing Specific Computer-Generated Spatial Tasks

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## ABSTRACT

Most computer applications feature visual user interfaces that assume that all users have equivalent propensities to perceive, interpret, and understand the multidimensional spatial properties and relationships of the objects presented. However, the hunter-gatherer theory (Silverman & Eals, 1992) suggests that there are modern-day differences between the genders in spatial and cognitive abilities that stem from differentiated prehistoric sex roles. If true, there may be discrepancies in how males and females differentially utilize particular spatial visual cues and interface features. We report three experiments in which participants engage in visual spatial tasks using 2D and 3D virtual worlds: (1) matching object shapes; (2) positioning objects; and (3) resizing objects. Female subjects under-perform male subjects in the matching and positioning experiments, but they outperform male subjects in the resizing experiment. Moreover, male subjects make more use of motion cues. Implications for the design of gender-effective user interfaces and virtual environments are considered.

## INTRODUCTION

A perennial trend in the evolution of computer technology relates to the ever-increasing power of hardware and the resulting burgeoning possibilities to develop more complex software. These trends have enabled the proliferation of more specialized and powerful computer applications that support users in a wide variety of personal

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and professional tasks. Associated with these trends are multiple challenges: (1) to make the presentation of geometrically increasing amounts of data ever more concise; and (2) to condense, convey, and present larger and larger volumes of useful information using smaller and smaller spaces. To meet these challenges, new and creative approaches to the design of visual user interfaces have emerged, many that present complex, multidimensional data sets and relationships into condensed visual forms and spaces.

Unfortunately, an implicit assumption in the design of commonplace visual user interfaces is that preponderant portions of the existing user population have similar abilities to cognitively perceive, process, interpret, and ultimately understand the intended visual and spatial properties of the objects presented. Yet, it is known that certain measures of spatial cognition are correlated with performance in user interface tasks (Cockburn, 2004). As an example of how individual perceptual differences can affect user interface design, professional Web designers are aware of color blindness patterns[1] in the general population that affect the ability to correctly perceive color-encoded information. As a result, professional designers of high-traffic Internet Web sites avoid these color blindness traps in order to enhance the universal usability of the sites.

Clearly, the assumption of equivalent user capabilities runs the risk of impairing the usability of visual interfaces that ignore broad, existing population anomalies in spatial cognitive and task performance abilities. Through the process of evolutionary natural selection, the hunter-gatherer theory (Silverman & Eals, 1992) ties modern-day, gender-based differences in certain cognitive, spatial abilities back to sharply differentiated sex roles from prehistoric times. Also, it is recognized in behavioral research communities that there are innate differences between the male and female genders related to cognitive spatial abilities (Kimura, 2000; Linn & Petersen, 1985; Voyer, Voyer, & Bryden, 1995). These gender differences may directly impact the ability to perceive, interpret, and cognitively process spatial properties and spatial relationships of multiple visual objects presented on a computer screen. Thus, there may be fundamental differences between the genders with respect to the ability to use certain visual user interface features, particularly when these features relate to the perception of depth and to the spatial relationships of objects and scenes presented at varying levels of intended depth.

In this article, we review theory and empirical studies relating to (1) gender and human computer interaction and (2) gender differences in innate spatial cognitive and task performance abilities. We then describe three experiments that examine gender-based performance differences in object matching, positioning, and size estimation tasks using two-dimensional (2D) and three-dimensional (3D) virtual worlds. The observed gender performance differences are discussed with respect to applicable theory and with respect to the design of gender-neutral user interfaces and virtual environments.

## THEORY AND BACKGROUND

### Gender and Human-Computer Interaction

Researchers long have acknowledged the relevance of gender as impacting human computer interaction. Gender has been noted as a broad issue affecting computer skills and computer design issues (Balka, 1996). Gender has been recognized as an important consideration for the design of user interfaces (Leventhal, Teasley, & Stone, 1994) and display techniques (Shneiderman, 1990) and as an issue relevant to achieving universal usability among diverse users of Web-based computer services (Shneiderman, 2000). Gender has been related to the process of decision making, to preferences for investment models, and consequently, as an important consideration

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