

Spatial ability and experts of needlework crafts an exploratory study

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SPATIAL ABILITY AND EXPERTS OF NEEDLEWORK CRAFTS:

AN EXPLORATORY STUDY

by

SHANNON KYLE TEDDER BAILEY

A thesis submitted in partial fulfillment of the requirements
for the Honors in the Major Program in Psychology
in the College of Sciences
and in The Burnett Honors College
at the University of Central Florida
Orlando, Florida

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Thesis Chair: Dr. Valerie Sims

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Abstract

Spatial ability has been a topic of much research and debate over the past few decades. Yet, there are gaps in the current literature. Spatial ability refers to the aptitude of an individual to mentally rotate objects, visualize spaces, and recognize patterns (Linn & Petersen, 1985). A highly spatial task that is not addressed in research literature is crafting. Crafting may refer to knitting, crocheting, sewing, and other hobbies that include manipulations of materials. These crafts are spatially oriented, because they necessitate mental rotation, pattern recognition, and 3-D visualization to create an object. While research tends to favor males on certain spatial tests (Voyer, Voyer, & Bryden, 1995), research on the relationship between expertise and spatial ability has concentrated on traditionally male dominated domains, such as architecture and video games (Salthouse & Mitchell, 1990; Sims & Mayer, 2002). The traditionally female domain of needlework crafting expertise has not been studied empirically.

First, a literature review is presented to give an overview of previous spatial ability research. The paper then describes the needlework crafts of sewing, knitting, and crocheting, including their historical significance and the spatial processes involved. A study was conducted to test the hypothesis that more expertise in needlework crafts will correlate with better performance on spatial ability tests. Three hundred and four adult women (ages 18-77) completed the study. Participant experience level was determined by self-perceived level of crafting expertise. Participants performed three spatial ability tests from the ETS Factor Reference Kit (Ekstrom et al., 1976): Paper Folding, Surface Development, and Card Rotations.

Results indicated that age was correlated negatively with performance in all spatial tests. Only age was significant in the Card Rotations Test. In the Surface Development Test, self-perceived Sewing Expertise was significant in predicting participants' test scores. For the Paper Folding Test, Knitting and Crocheting Expertise were significant, suggesting expertise may mitigate age effects.

Dedication

For my grandmothers, who are experts at everything.

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Introduction

Spatial ability has been a contentious topic in cognitive research, with many areas left to be addressed in future research. First, there is debate over what exactly is spatial ability. Although there are studies addressing spatial tasks in various populations, researchers have noted a lack of clear definition of spatial ability from which to operate (Voyer, Voyer, & Bryden, 1995). Linn and Peterson (1985) offer a concise definition, stating spatial ability is “skill in representing, transforming, generating, and recalling symbolic, nonlinguistic information” (p. 1482). The search for a standard description of spatial ability brings the study of spatial tasks into question. Researchers point out that performance on spatial tasks can be measured, but their validity is uncertain. It is unknown to what extent these tests represent one’s spatial aptitude. Therefore, it is necessary to continue obtaining data on different spatial tests with varying populations, so a better understanding of spatial ability can be formed.

Previous research on spatial tasks has yielded interesting results. Notably, studies of spatial ability indicate that men tend to outperform women on certain tasks (Linn & Petersen 1985; Maitland, Intrieri, Schaie, & Willis, 2000; Voyer, Voyer, & Bryden, 1995). Meta analyses suggest that this sex difference is particularly evident in tasks of mental rotation (Voyer et al., 1995). Researchers are interested in studying why this gap may exist. Some lines of study attribute the gap to evolutionary sex differences in spatial perception, whereas other studies predict socialization is the key factor in gender differences (See Jones, Braithwaite, & Healy,

2003, for a review of evolutionary theories; see Moè, Meneghetti, & Cadinu, 2009, for gender review). However, spatial ability has not been studied in many traditionally-female domains, such as needlework crafts, although it has been studied in traditional male domains, such as videogames (Sims & Mayer, 2002). Another area of interest in spatial ability research is expertise. Some literature indicates that there is little to no crossover between expertise of a spatial activity to similar spatial tests. In one such study (Sims & Mayer, 2002), participants who were experts at the mental rotation game of Tetris performed no better than Tetris novices on a mental rotation test. Yet other research on male architects indicated that the architects performed better on spatial tests than their non-architect counterparts (Salthouse et al., 1990). Other research shows that there is a decline in spatial ability with age (Maitland, Intrieri, Schaie, & Willis, 2010). Although many aspects of cognitive functioning tend to decline at increased ages, there is still much room for research on the elderly population and spatial ability. Particularly, cognitive maintenance of spatial ability is one area that needs further exploration.

A real-world example of spatial tasks is crafting. Expertise in crafts has yet to be studied from a spatial perspective, although they require many spatial tasks, such as mental rotation, object formation, and pattern recognition. While crafting can refer to any creative hobby from paper card making to woodwork to floral design, the needlework crafts of sewing, knitting, and crocheting were picked for several reasons. First, industry surveys indicate that these crafts are among the most popular creative and leisure hobbies in North America (CraftPR, 2011). These

crafts are also popular in different age demographics, with a growing number of younger crafters (Craft & Yarn Council, 2011). Ultimately, needlework crafts provide a way of studying spatial expertise in populations that are underrepresented in the research, namely elderly women. It is important to incorporate the elderly and female demographic to build an inclusive understanding of spatial ability. Research on crafts may provide insight on how spatial ability is affected by practical application, expertise, and age.

This paper explores expertise in crafting and its correlation to spatial ability. First, a literature review is presented to give an overview of previous spatial ability research. The paper then describes the needlework crafts of sewing, knitting, and crocheting, including their historical significance and the spatial processes involved. Finally, an experiment was conducted to test the hypothesis that more expertise in these needlework crafts will correlate to better performance on selected spatial ability tests. Participant experience level was determined by self-perceived level of crafting expertise. Participants performed three spatial ability tests from ETS Factor Reference Kit (Ekstrom et al., 1976): Paper Folding, Surface Development, and Card Rotations. Discussion of the results addresses implications for future research on the study of spatial ability and crafts.

Literature

Spatial Ability

Although the topic itself seems commonplace, defining an operational definition of spatial abilities has been almost as controversial as empirical results. In a meta-analysis of spatial ability studies, Voyer et al. (1995) discuss the lack of clear definition of the subject and the subsequent controversy over significant results found. They suggest that because different tests were used to measure spatial aptitude, it is difficult to compare experiment results in the broad and sometimes ambiguous category of spatial abilities.

Several meta-analyses have addressed the issue of assessing the large and varying amount of research on the subject. Linn and Petersen (1985) offer the definition of spatial ability as, “skill in representing, transforming, generating, and recalling symbolic, nonlinguistic information” (p. 1482). They further breakdown spatial ability into three subcategories via factor analysis: spatial perception, mental rotation, and spatial visualization. Yet, Voyer et al. (1995) hypothesized that spatial ability is not a unitary concept and that “Linn and Petersen (1985) oversimplif[y] the relation among measures of spatial performance” in order to fit them into three subcategories. However, Voyer et al. (1995) find in their meta-analysis that Linn and Petersen’s partitions of spatial ability do show significant results when similar spatial tasks are tested together. Thus, Linn and Petersen’s definition and divisions of spatial ability appear useful as a theoretical foundation for the following literature review.

Age

Age related declines in cognitive functioning have been found in research studies (Maitland, Intrieri, Schaie, & Willis, 2010). Yet, literature concerning the elderly population is lacking. The literature varies on the degree to which spatial abilities decline with age, especially when spatial ability is broken down into different tasks, such as mental rotation and Piaget's water level task (Tran & Formann, 2008; Voyer et al., 1995). One meta-analysis of 91 studies on age and cognitive variables, including spatial ability, was conducted by Verhaeghen and Salthouse (1997). Although age related declines in adulthood were seen across all five categories of cognitive variables, spatial ability was among the most negatively correlated factors when weighted for sample size. Across these studies, spatial ability declined as age increased in older adulthood. However, in a recent article by Tran and Formann (2008), the researchers discuss limitations of previous studies on spatial ability involving elderly participants. The authors point out that participants were often small in number and sampled from areas of higher education, restricting application of results toward a general elderly population. It is important, therefore, to expand literature on spatial ability in this age group from representative backgrounds.

In acquisition of spatial knowledge, older adults tend to perform worse than younger adults. In a study by Jansen, Schmelter, and Heil (2010), the researchers tested acquisition of spatial knowledge in younger and older adults with a virtual maze. Participants were grouped in three age categories: younger adult (ages 20-30), middle-aged (ages 40-50), and older adult

(ages 50-70). Amount of computer use was similar across each age group. Participants then were asked to learn the correct route through a maze based on markers given in the virtual environment. The younger adults took significantly fewer trials ($M=2.55$) than middle-aged ($M=4.10$) or older adults ($M=6.00$) to correctly learn the maze. This study suggests that older adults acquire spatial knowledge less readily than younger adults. Yet, this experiment focused on spatial awareness in learning a new environment. Spatial abilities that are involved in crafts may involve different skills. Additionally, these skills are usually developed over years of practice in craft hobbies. So, although research may suggest that older adults adopt new spatial skills less readily, research should also address spatial tasks in which older adults already actively participate, such as crafting.

An area of spatial ability that has shown significant declines with age is mental rotation speed. Mental rotation is the ability to visualize an image as it is turned 360 degrees or turned at different 3-dimensional angles. An earlier study by Berg, Hertzog, and Hunt (1982) tested speed and accuracy of mental rotation with four adult age groups: Group 1 (ages 18-24), Group 2 (ages 26-35), Group 3 (ages 44-58), and Group 4 (ages 60-69). Accuracy and speed were measured for the task of determining whether an image was the same as the original image, just rotated. Over a four day period, they had each adult perform over 100 trials of the task. Results showed significant declines in speed of answering with age increase. Yet, significant differences were not shown for accuracy of answers. Interestingly, declines in speed with

increased age did not diminish over the four day period of trials, suggesting that practice does not alleviate the differences in mental rotation speed with age.

As previously mentioned, the validity of these tasks as they relate to spatial ability has been questioned by researchers. Tran and Formann (2008) note that performance on certain tasks (such as Piaget's water level test) was worse on paper-and-pencil versions of the test than when participants were given the hands-on test (p. 233). This paper, therefore, posits that it is important to study these spatial tests in relation to how they are applicable to common activities. For example, knitting necessitates visualization of the created object as it is rotated and formed. Assessing whether performance on mental rotation tests correlates with skills of crafting will indicate to what extent a connection can be made.

Gender

It is well-established in the literature that males tend to outperform females on measures of spatial ability, with the degree of this difference depending on the task (Hyde 1981; Kaufman, 2006; Linn & Petersen 1985; Maitland, Intrieri, Schaie, & Willis, 2000; Voyer, Voyer, & Bryden, 1995). Yet, Hyde (1981) notes in a meta-analysis that gender differences are small in tests of cognitive aptitude, and even the largest gender gap of spatial ability only accounts for less than 5% of population variance. In these spatial tests, mental rotation is performed consistently better on average by men than by women, especially when the object rotated is 3-D (Voyer et al., 1995). This gender gap was seen across adult age groups (Linn & Petersen, 1985; Maitland, et al. 2000), although other tests of spatial perception or

visualization do not indicate the same degree of sex difference shown in mental rotation.

However, some research indicates that the gender gap disappears with practice on certain spatial tasks (Kass, Ahlers, & Dugger, 1998).

Numerous theories have been proposed that attempt to explain why a sex difference in spatial ability may exist. Some researchers suggest that this difference is biologically based, evolving with the human species. Jones, Braithwaite, and Healy (2003) give a review of prominent evolutionary explanations to spatial ability and sex differences across species. Of the hypotheses examined, the authors found that most evolutionary explanations lacked substantive support. The theory with the most reasonable evidence was the “Range Size” hypothesis, which proposes that spatial ability favors males of a species in which males must travel further than females to reproduce. Although these evolutionary theories need further investigation, biological studies provide evidence that hormones contribute to differential spatial abilities. Research indicates that higher levels of testosterone are correlated positively with spatial ability and higher levels of estradiol are correlated negatively (Hausmann, Slabbekoorn, et al., 2000). Men usually have higher testosterone and women have higher estradiol.

Yet, other researchers expect that differences in gender socialization play a key role in spatial development. Moè, Meneghetti, and Cadinu (2009) note that boys in Western culture are more encouraged than girls to participate in spatial activities, such as video games, building toys, and math/science courses, because spatial ability is considered a masculine trait.

However, researchers points out that in many rural and non-literate cultures, women routinely perform tasks that require spatial skills “such as weaving, knotting hammocks, and constructing temporary shelters...” (Pontius, 1997a, p. 779). Several cross-cultural studies challenge the gender gap in spatial tasks. For example, Pontius (1997a) conducted a study in a rural community of northwest Pakistan. When the elementary school children (boys and girls, ages 8 to 10 years) were given spatial ability tasks, no difference was found between the genders. Another study conducted by Pontius (1997b) found supporting results in a rural community in Ecuador. In this research, there was no significant difference shown between boys and girls (ages 9 to 10 years) on spatial tasks, including a test of mental rotation. The author noted that girls in this community routinely participated in “sewing, needle work, weaving, and knotting, which require spatial representation (p. 72).” These cross-cultural studies suggest that cultural and environmental factors, practice effects, and expertise also may contribute to one’s spatial aptitude.

Expertise

Defining the term *expert* is largely dependent on the field. In an article on the theory of expertise, Gobet (2005) gives examples of attributes that experts commonly portray, such as having skill well beyond that of a novice, having perceptual ability that allows efficient problem solving, and extensive experience of usually at least ten years. Determining what makes an expert in various tasks involving spatial skills also is decided predominately by the activity itself. For example, many studies have been conducted on chess, because it is easy to differentiate

level of expertise based on the competition (Gobet, 2005). The literature on expertise also focuses on whether expertise in one area is specific to that domain or if spatial skills can cross over into other domains.

The crossover of a spatial skill into another area is referred to as *expertise effect*, whereas a skill applicable to one area is deemed *domain specific*. One study (Sims & Mayer, 2002) looked at experts of the classic video game Tetris to see if the mental rotation necessitated in the game was domain specific. When Tetris experts completed measures of mental rotation, however, experts performed no better than novices, and an expertise effect was not found. In contrast, Salthouse et al. (1990) had male architects of different ages complete several measures of spatial ability (including the Surface Development Test and Paper Folding Test which are used in the current study). These architects outperformed their non-architect peers for each age level, indicating that there may be some degree of expertise effect on measures of spatial ability. However, as Cavallini, Cornoldi, and Vecchi (2009) point out, research is unclear as to whether practice develops spatial skills or if people who have a natural cognitive ability are more inclined to participate in spatial activities. Much of this research tends to be in traditionally male-dominated domains (e.g. video games, architecture), and should be explored in traditionally female domains such as needlework crafts.

Training does seem to have an impact on spatial ability tests. For example, McGee (1978) found that both men and women benefitted from three weeks of training on a test of mental rotation. This result was supported in Kass, Ahlers, and Dugger (1998), who found that

repeated training on a spatial ability measure improved performance that was still shown after three weeks. Furthermore, this training also alleviated gender differences between participants. Practice effects may be part of an expertise crossover between one's daily activities and spatial aptitude.

Crafts

Needlework crafts such as sewing, knitting, and crocheting are important to study, because they may impact quality of life for the millions who participate. Crafts are well-established leisure activities today, with 56% of U.S. households surveyed reporting that they participated in crafting at least once in 2010 (CraftPR, 2011). Several studies link these crafts and other creative pastimes to improved health, wellbeing, or satisfaction with life. In a study on quality of life in Canada, Michalos (2005) found that satisfaction with overall quality of life was correlated positively with satisfaction gained from knitting or crocheting across demographics. Additionally, crafting and other hobbies can be used for stress reduction. In a large survey of over 5,000 respondents conducted for the Craft Yarn Council (2011), 64% of those who knit or crochet reported doing so to relax. Respondents in another study (Utsch, 2007) completed a questionnaire on knitting and a measure of perceived stress level. Results suggested that many knitters do indeed use their pastime for stress-relieving purposes and that knitting had a positive impact on reduced stress level.

Among other possible benefits of crafting are their potential to improve or maintain motor and cognitive functioning. Research suggests that keeping the mind active helps

maintain cognitive processes (Geda et al., 2011), but studies directly exploring crafts and spatial ability are incredibly minimal. At the time of this paper, only one study could be found linking spatial ability and crafts. In the study by Holzinger and Swineford published in 1946, the authors suggested that high school students who performed well in a “shops and crafts” course also earned better grades in Geometry. More research needs to be conducted to yield insight on the possible effects of sewing, knitting, and crocheting.

Across history and culture, there are many different arts and crafts that involve manipulation of materials to create new products. A craft can be a trade or hobby that often requires manual skill and creativity to produce a final work. Anything from woodworking and glassblowing to embroidery and floral decorating can be considered a craft. Today, crafts are considered leisure pastimes, as they are usually done in one’s spare time and are not the main source of income. Although there are many different crafts, most of which are highly spatial in nature, the scope of this research is limited to sewing, knitting, and crocheting. Focusing on these specific crafts can provide a basis for further spatial research on other areas of craft hobbies.

Sewing, knitting, and crocheting were chosen, because they are popular in modern culture and represent many of the spatial skills used in other areas of crafting. These skills can include mental rotation, pattern recognition, and building three-dimensional objects. Additionally, sewing, knitting, and crocheting are widespread endeavors today. Determining

the current prevalence of various crafts and the demographics of crafters is difficult, however, because information from disinterested sources is limited.

Several industry studies give an overview of the popularity of these crafts. In a 2010 survey of 114,200,000 households in the United States for the Craft and Hobby Association (CraftPR, 2011), knitting and crocheting made a list of top ten crafts by household participation (sewing was divided into multiple other categories). Crocheting was ranked third, with 17.4 million households participating in 2010, whereas knitting ranked ninth with 13 million responses. More young crafters are becoming involved with these needlework activities, according to a Craft & Yarn Council report (2011). This indicates that these crafts are growing in popularity and are seen in all diverse groups.

Sewing

Sewing, the system of stitching together cloth with a needle and thread, has been a necessary task for most societies in history. Spanning across cultures and thousands of generations, people (traditionally women) sewed at home to create clothing or household items to meet personal and familial needs. While sewn artwork also can be seen as far back as ancient civilizations, the mass shift from home sewing as a mundane obligation to a leisure hobby has been a relatively recent phenomenon.

Sherry Schofield-Tomschin (1999) traces this shift from need-based sewing to sewing for pleasure in a study on motivational changes in home sewing during the 20th century. The ease and popularity of home dressmaking grew with the invention of the home sewing machine in

the mid-19th century. As the market for home sewing grew in America, so did the materials evolve. Fabrics and patterns were more available at higher quality and lower costs. Women were able to quickly and more cheaply make garments for their families. Schofield-Tomschin notes that poor economic conditions and the relative value of home dressmaking was the main motivator of home sewers in the first part of the 20th century. Schofield-Tomschin cites the 1925-1926 survey by O'Brien and Campbell in which 90.2% of respondents said the lower cost of homemade clothing was the main factor in their home sewing.

In contrast, changes in the economy and social landscape of the later 20th century are attributed to the decline in home sewing. As the economy flourished in the 1980's and 90's, it was easier to buy clothing from stores, and home sewing was no longer a necessity. More women entered the workforce, and it was less cost efficient for women to spend their limited time at home sewing clothes.

Yet, as home sewing for need decreased, sewing as a leisure pastime grew. Schofield-Tomschin (1999) gives several studies to support this claim. Between 1973 and 1990, more middle to upper income households were sewing than lower income homes, reflecting the 1985 analysis by Loker that home sewing was more expensive than buying ready-to-wear clothes. Additionally, studies starting in the 1980's suggested that creativity was the motivation for home sewing over economic factors. The declining need for home sewing gave way to sewing as a craft hobby.

Today, home sewing is often done on a tabletop sewing machine and is less frequently done by hand stitching. Paper patterns are often used to cut shapes out of fabric which are then stitched together. The most apparent spatial skill used in sewing is being able to visualize the development of a three-dimensional object by correctly matching ambiguous shapes. Other spatial skills are involved when one must place a button hole by visualizing the fold of fabric, or cut fabric on the fold so that the final shape is symmetrical, or recognize geometric patterns which will become a sleeve versus a pant leg. Spatial tests that measure 3-D development should be explored with sewing experts.

Knit

Modern hand-knitting involves creating a pattern of interlocking loops of yarn using multiple needles. While similar looking stitches were created using various methods since ancient times, the established process of knitting today has been traced to Arabic North Africa around 1,000 C.E (Nicholson, 1998). There may be even earlier examples of hand-knitting dating back to Asia around 700 B.C.E, but the history is still largely unknown (Harris, 1993, p. 46). By the 13th century, knitting had spread to Western Europe, where it continued to grow into an industry. Knitting became a major business during the Renaissance, as expensive knit stockings were made and imported across Europe and England. Because it was a portable skill and materials could be acquired rather cheaply without much wasted material (unlike the leftover fabric in sewing), hand-knitting was a popular trade for lower and middle class families. Although knitting is seen as a traditionally female task, it was common that men, women, and

children participated in creating knitted garments to earn income up until the 19th century. Men even formed knitting guilds during the 16th – 18th centuries, until it became a lady's leisure activity in the late 18th and 19th centuries.

Hand-knitting as a primary means of support drastically declined with the Industrial Revolution. Machine knitting, which was always more behind fashion than adaptable hand-knitting, suddenly surpassed the hand-made process in productivity. As hand-knitting for income decreased, knitting for pleasure became the norm. Knitting and other needlework typically have been done socially and were conducive to a lady's leisure activities. The middle and upper class women took up the pastime of knitting as a creative and social outlet, whereas poorer families continued to knit as a means of survival. Today, knitting is considered a leisure pastime along with other needlework crafts.

The process of knitting involves many spatial skills from the knitter. Because knitting is a series of interlocking stitches of various constructions, pattern recognition is central to creating an item. Even if the knitter is following a written pattern, she must carefully determine which type of stitch goes next to create an intricate braided ribbing design. Mental rotation also may play a part as one must turn the item as it is being stitched to create different shapes. This is especially true when an item is being stitched in a round, which is formed by increasing concentric circles in various patterns. Spatial visualization of two and three dimensional objects is also a large factor in knitting, as forms must come together to complete an object.

Crochet

Similar to knitting, crochet is a process of interlocking stitches. Unlike knitting, crochet uses a single hook instead of two needles to work the yarn. Although crocheting rivals knitting in popularity today, crochet is a much younger form of needlework. Also called “imitation lace” or “nun’s lace,” Potter (1990) indicates that crochet may have been created in Renaissance Italy but was not popular until the early 19th century. The author notes that crochet was considered a “leisure art” in the 1830’s, which it is still considered today.

As with other crafts, the process of crocheting varies by personal preference. Depending on the number of times a loop is pulled through a stitch and the placement of the stitch, different crochet stitches are formed, such as double crochet, half-double crochet, triple crochet, etc. To create an item with crochet, many people follow a pattern. There are many different forms of crochet patterns, none of which are completely standardized. Commonly, a pattern will be done in rows straight across or worked in rounds about a central ring. Patterns can be written out using abbreviations (e.g. “ch” for chain, “dc” for double crochet, “yo” for yarn over, etc.), or they can be in picture form using line symbols or a grid. For example, filet crochet is a mesh-like pattern that is formed by following a design on a grid. It can become a complicated pattern of square “spaces” (several skipped stitches to form an open space) and “blocks” (several stitches in a row). Experts of crochet might need to visualize the pattern shape being extended to fit a desired size or flipped and rotated to achieve a desired pattern. This involves extensive math and geometry as small stitches are counted, patterns are

recognized, and shapes are mentally rotated and translated in two or three dimensions. The variability of patterns, subjective creativity, and complexity of design make this kind of needlework a highly cognitive process.

Methods

Participants

To obtain a sample of crafting experts, adult women ranging in age from 18 - 77 years old were recruited online through networking sites, including the crafting website Ravelry. Three hundred and four women completed the study. All participants expressed an interest in crafting, the degree to which was measured in a questionnaire. To obtain the self-perceived level of crafting expertise, participants were asked the following Likert scale question for each craft area (sewing, knitting, and crocheting):

1. I am good at knitting (/crocheting/sewing).

(0) I do not knit (/crochet/sew), (1) Strongly Disagree, (2) Somewhat Disagree, (3) Undecided, (4) Somewhat Agree, (5) Strongly Agree

Expertise was parsed into the three areas (Knit [0-5], Sewing [0-5], Crochet [0-5]) to determine which variable(s) showed significance in regression analyses. The overall level of self-perceived crafting expertise was calculated by summing 0-5 across the three questions, making the highest possible score 15. For example, if a participant responded that she Strongly Agreed (5) she was good at sewing, knitting, and crocheting, her score for perceived crafting expertise would be 15. The lowest recorded score for participants was 4, and the highest score was 15. Overall expertise was used, because crafters often participate in several types of craft activities. Self-reported expertise was significantly correlated between the crafts. Perceived

knitting expertise and crochet expertise had a significant negative correlation, $r = -.155$, $p = .008$. This means that participants were less likely to rate themselves the same for knitting expertise and crochet expertise. However, Knitting expertise and sewing expertise were correlated positively, $r = .181$, $p = .002$. Sewing Expertise and crochet expertise were also correlated positively, $r = .243$, $p < .001$. These correlations mean that a participant was more likely to give similar ratings for their sewing and crocheting expertise or sewing and knitting expertise.

An additional measure of reported frequency of time involved in each of the three craft areas was collected. The frequency which a participant reportedly spent was included as a variable in regression analyses. Participants were asked the following Likert scale questions:

1. How often do you knit (/crochet/sew)?

(0) Never, (1) Over a Year Ago, (2) A Few Times a Year, (3) Monthly, (4) Weekly, (5) Daily

Procedure

The participants completed a questionnaire including demographics, self-perceived level of crafting expertise in knitting, crocheting, and sewing, self-reported frequency of crafting, and three spatial ability tests from the ETS Factor Reference Kit (Ekstrom et al., 1976): Paper Folding, Card Rotations, and Surface Development.

Materials

Paper Folding Test

Participants were given ten questions to complete in three minutes. A question on the Paper Folding Test consists of images on the left depicting a piece of paper being folded. There are holes punched completely through the folded paper. On the right, there are pictures of an unfolded paper with holes. The participant must match the corresponding unfolded picture on the right with folded paper on the left.

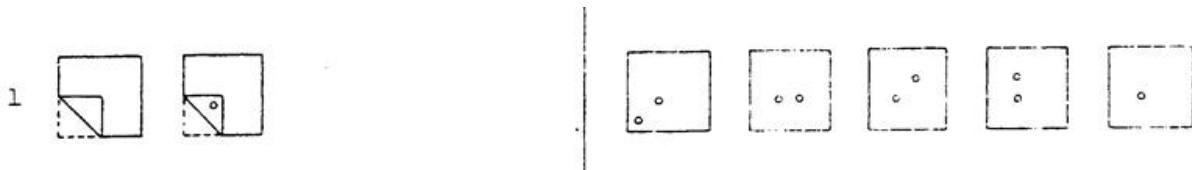


Figure 1: Paper Folding Test Question Example

Card Rotations Test

Participants were given a Card Rotation test of ten cards consisting of eight questions each. The objective of the task was to determine if the card (shape) on the left matches the cards (shapes) on the right. The cards on the right can be rotated 360 degrees but *not* flipped, to be considered the same as the card on the left. Participants marked if each of the cards on the right matched the card on the left.

To score the Card Rotations Test, a point was given for each answer that was correctly marked as matching. The highest possible score was 42. Participants were removed from

analysis if they did not respond to any of the questions, therefore one hundred twenty-six were removed. A Regression was conducted with the one hundred seventy-two participants with the variables Age, Knit Expertise, Sewing Expertise, Crochet Expertise, Knit Time, Sew Time, and Crochet Time.

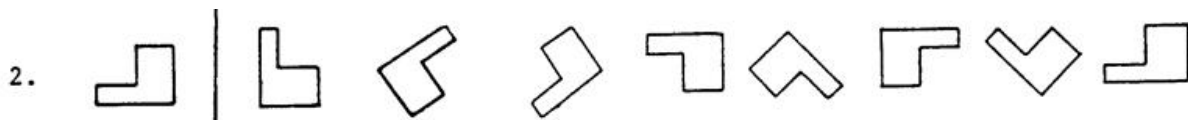


Figure 2: Card Rotations Test Question Example

Surface Development Test

Participants completed ten items with five parts each, in which they were instructed to imagine the three-dimensional object shown being folded and unfolded. The participant had to match the number on an edge of the unfolded object to its corresponding edge on the folded object. To score the test, participants had to answer at least half of the questions (≥ 25) to be included. One hundred twenty-seven participants were included in the analysis.

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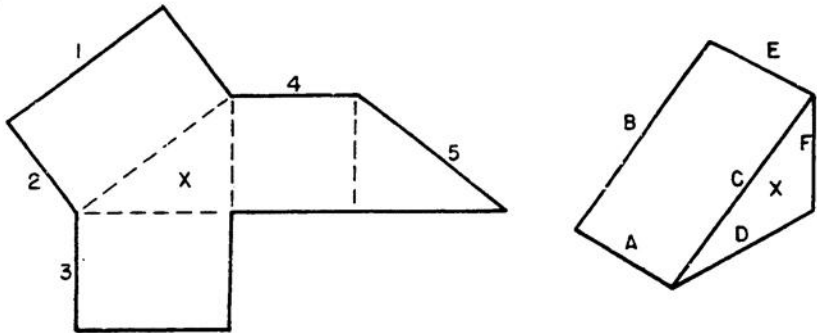


Figure 3: Surface Development Test Question Example

Results

For each of the spatial ability tests, stepwise multiple regressions were used to determine which variables may be significant. The variables used in each regression were Age (continuous), Knit Expertise, Crochet Expertise, Sewing Expertise, Knit Time, Crochet Time, and Sewing Time. The expertise variables were the self-perceived ratings in each craft [0-5], and the time variables were the time spent in each craft [0-5] as described in the *Participants* section.

Analysis of Card Rotation Test

A stepwise multiple regression was conducted with Age, Knit Expertise, Knit Time, Crochet Expertise, Crochet Time, Sewing Expertise, and Crochet Time as predictor variables and Card Rotation Test Score as the outcome variable. The regression indicated that only the model using Age was significant, $R^2 = .13$, adjusted $R^2 = .125$, $F(1, 171) = 25.62$, $p < .001$. Age was the only significant predictor of Card Rotation Test Score, $t(171) = -5.06$, $p < .001$.

Analysis of Surface Development Test

A stepwise multiple regression was conducted with Age, Knit Expertise, Knit Time, Crochet Expertise, Crochet Time, Sewing Expertise, and Crochet Time as predictor variables and Surface Development Test Score as the outcome variable. The regression indicated that the model using Sewing Expertise as a predictor of Surface Development Test Score was significant, $R^2 = .041$, adjusted $R^2 = .033$, $F(1, 126) = 5.38$, $p = .022$. In this model, Sewing Expertise was

significant, $t(126) = 2.32, p = .022$. The model including Sewing Expertise and Age was also a significant predictor of Surface Development Test Score, $R^2 = .08$, adjusted $R^2 = .065$, $F(2, 125) = 5.43, p = .005$. Sewing Expertise was a significant, $t(126) = 2.96, p = .004$, and Age was significant, $t(126) = -2.30, p = .023$.

Analysis of Paper Folding Test

A stepwise multiple regression was conducted with Age, Knit Expertise, Knit Time, Crochet Expertise, Crochet Time, Sewing Expertise, and Crochet Time as predictor variables and Paper Folding Test Score as the outcome variable. The regression indicated that the model including Age was useful, $R^2 = .22$, adjusted $R^2 = .217$, $F(1, 289) = 81.57, p < .001$. In this model, Age was a significant predictor of Paper Folding Test Score, $t(289) = -9.03, p < .001$. The next significant model included Age and Knit Expertise, $R^2 = .235$, adjusted $R^2 = .230$, $F(2, 288) = 44.32, p < .001$. For this model, Age was significant, $t(288) = -9.13, p < .001$, and Knit Expertise was significant, $t(288) = 2.394, p = .017$. The final significant model used the variables Age, Knit Expertise, and Crochet Expertise, $R^2 = .246$, adjusted $R^2 = .238$, $F(3, 287) = 31.18, p < .001$. The variables had the following significance: Age, $t(287) = -9.40, p < .001$; Knit Expertise, $t(287) = 2.70, p = .007$; and Crochet Expertise, $t(287) = 2.00, p = .047$.

Discussion

The hypothesis that crafting expertise is related to better performance on spatial ability tests had mixed results for the three tests. The hypothesis was not supported in the Card Rotations Test, which did not suggest a correlation between any of the areas of craft expertise on test scores. Yet, results indicated perceived sewing expertise may be an important factor for the Surface Development Test, and perceived knit or crochet expertise was significant for the Paper Folding Test. For each of the tests, age was correlated significantly with test score. This was consistent with current literature that cognitive abilities decline with increased age (Maitland, Intrieri, Schaie, & Willis, 2010). Reported time spent on each craft area (sew, knit, crochet), did not predict performance on any spatial test. However, this measure was not specific enough to find variability or validity, because the scale covered such large time segments (Daily, Weekly, Monthly, A Few Times a Year, Never). To more accurately assess if craft practice time impacts spatial ability performance, future research should be more time specific (such as asking how many hours are spent crafting per period of time).

On the Card Rotations Test, only age was a significant predictor of Card Rotation Test performance. As age increased, the participant's score decreased. Perceived crafting expertise for sewing, knitting, and crocheting did not indicate any significant correlation. This was consistent with previous tests of expertise and spatial ability that suggest expertise is domain specific and does not translate to the Card Rotation Test of mental rotation (Sims & Mayer, 2002).

In the Surface Development Test, age also was correlated negatively with spatial test performance. Interestingly, perceived sewing expertise also predicted Surface Development score. Although increased age hurt Surface Development score, sewing expertise was correlated with better test performance. This result made sense for the Surface Development Test, which involved matching edges of a flattened 3-D object to their corresponding sides on an assembled 3-D object. The spatial visualization needed to complete the Surface Development test was similar to the process in sewing of putting together garments. When sewing a piece of clothing, one must match correctly edges of various pieces to assemble a garment. Future research should include measures of 3-D object development and other similar spatial visualization tests to further examine this link between spatial ability and sewing expertise.

Just as in the previous tests, age was correlated negatively with performance on the Paper Folding Test. However, perceived expertise in Knitting and Crocheting did predict positively Paper Folding scores. This connection between knitting, crocheting, and the Paper Folding Test was less easy to explain than the connection between sewing and Surface Development performance. The Paper Folding Test involved visualizing a paper with a hole punched through being unfolded. It would seem that tasks in sewing would use similar visualizations, such as cutting selvage from folded cloth or placing a buttonhole. However, Knit and Crochet Expertise showed a positive correlation on the Paper Folding score and Sewing Expertise did not have a significant effect. At this point, only speculation of what is involved in knitting or crocheting can suggest why these participants performed better on the Paper

Folding Test. Further research could delve deeper into this area of spatial ability and more areas of pattern recognition to understand what components of knitting and crocheting cross spatial domains.

This study showed that there is an area of spatial ability research that remains to be addressed and which may augment spatial ability theory. Results of these three tests were consistent with previous literature showing declines of spatial ability with age (Maitland, Intrieri, Schaie, & Willis, 2010). Yet, results also indicated a moderate effect for crafting expertise which mitigates the decline of spatial score in older age groups. Additionally, this test was conducted on the computer, which may be a disadvantage to those in the elderly population often with less technology experience than younger generations. It is important to continue this line of investigation between spatial ability and crafting, but reevaluate how to test on an even playing field. Furthermore, on the Surface Development Test and Paper Folding Test, expertise in an area of crafting did predict higher spatial test scores. There is still debate over whether experience in spatial activities can cross into other spatial domains. Research on crafting experience is a way to include previously understudied populations (namely elderly women) into this conversation of spatial expertise and domain specificity.

Practical implications from this study should be a focus of future research. In both the Surface Development Test and Paper Folding Test, those with certain crafting expertise performed better. If this connection holds up in future research, it could mean several things. First, that practice and skill in an area of crafting helps spatial ability. If this is further

supported, it may be useful to encourage crafting for cognitive development. Some private grade schools already include knitting as part of the curriculum, because they suggest it improves spatial and math skills (Richtel, 2011), but no other research currently exists to address this claim.

Another possible implication is that people who are inclined to do spatial activities, such as crafts, may be more spatially oriented. Some research tries to predict future performance in STEM (Science, Technology, Engineering, and Math) disciplines based on early interest in spatial activities (Wai, Lubinski, Benbow, 2009). More research could evaluate if interest in crafts may be indicative of spatial aptitude and future ability in areas of math, art, etc.

Finally, this research may mean that one's confidence in an activity labeled "spatial" may make one feel more capable of performing on standardized spatial tests. Because this study measured perceived levels of craft expertise, it may be merely confidence that correlates to better spatial test performance. Expectation may play a bigger role in spatial aptitude tests than we currently recognize. In that case, the pervasive cultural message that young men are much better than women and older adults at spatial ability may be detrimental to women and the elderly (see the literature review on gender differences for a research overview). Also, age effects on spatial ability may be mediated by expertise in crafting. Practice of crafts might help maintain spatial or cognitive abilities with age. A recent large survey by Geda et al. (2011) of elderly participants ($N = 1,321$, ages 70 to 89) indicated that participation in cognitive activities including crafts (defined as quilting, pottery, knitting, etc.) had decreased odds of having Mild

Cognitive Impairment (MCI, or mild dementia, p. 152). The positive correlations of crafts and spatial performance in this current study should not be construed as causation, but more research needs to be done to see if crafts may help develop or maintain spatial abilities.

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