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Mental Rotation with Martial Arts Expertise

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MENTAL ROTATION WITH MARTIAL ARTS EXPERTS

by

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Abstract

This research aims to investigate whether expertise, specifically martial arts expertise, is transferrable across domains, which would indicate spatial skills in one task can also apply to a seemingly unrelated one. In this study, reaction time during a mental rotation task was compared between experts and novices. Participants were shown two images and had to decide if the images were the same or mirror reflections. The images were comprised of Shepard-Metzler blocks, people in martial arts poses, and people in neutral poses. The results suggest expertise is not transferable across domains. While experts outperformed novices with some of the martial arts stimuli, there was not a significant difference with the neutral poses. Novices performed better than experts with the Shepard-Metzler blocks. This suggests experts may have embodied some of the stimuli to facilitate faster reaction times. Further research must be conducted to investigate if any type of expertise is transferable across domains, which could assist in the development of employee training programs, and to validate the human figures used as stimuli.

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Introduction

Past research has shown the importance of mental rotation tasks. During these tasks, participants can be asked a few questions. In one variation, participants are shown two images simultaneously. One image is either rotated in a different orientation from the other, or it is rotated in a different orientation and is made into the mirror image of the other. They are then asked whether, when mentally rotated, the two images are congruent or whether they are mirror images (Shepard & Metzler, 1971). Researchers measure the time it takes participants to press a key on a keyboard indicating whether the images are the same or different. Error rates are collected. In one variation, participants are shown body images that can clearly be defined as left and right, such as a man with his right arm extended or an image of a left hand (Ionta & Blanke, 2009). They are shown one image at a time. Then, participants are asked whether the image they see is a right-hand image or a left-hand image. In this task, instead of the two keys indicating same or different, one key indicates right-hand while the other indicates left-hand. Researchers are still interested in measuring reaction times. Reaction time increases as the angular disparity between the two figures increases (Shepard & Metzler, 1971).

Mental rotation tasks can provide insight into spatial ability and show how people are capable of mentally transforming two and three-dimensional objects in the real world (Habacha, Lejeune-Poutrain, Margas, & Molinaro, 2014). Transfer of expertise has historically been investigated in the cognitive realm, with researchers believing expertise did not transfer from one domain to another (Chase & Simon, 1974). The results initially were not different with expertise and mental rotation (Sims & Mayer, 2002). However, research began to reveal that the type of expertise mattered. People who are experts at performing body rotations do better overall on mental rotation tasks than novices (Dolléans, Hauw, Day, & Saramejane, 2011). This was extremely important, as it showed that expertise may not just be domain-specific. If it were, the experts only would have performed better when the images closely resembled their realm of expertise. While experts did perform best when the images were related to their area of expertise, they still consistently outperformed novices when the stimuli resembled the three-dimensional blocks used by Shepard and Metzler (Dolléans, Hauw, Day, & Saramejane, 2011).

One possible explanation is that experts may have more well-developed schemata of the stimuli used (Amorim, Isableu, & Jarraya, 2006). Schemata are ways people organize information in their minds (Johnston, 1995). Bartlett, who introduced the term "schema," believed past knowledge and experiences mold the way the mind processes future input (Johnston, 1995). For instance, a person's schema for happiness may include smiles where people show their teeth. If that same person were to see a primate bare its teeth, he or she may erroneously believe the primate to be happy when in fact it is expressing aggression. With regard to mental rotation, experts may have a plethora of mental images stored in their schemata of their different domains of expertise. When the stimuli used in experiments resemble the materials used in their domains of expertise, they have a large number of mental representations with which to compare the images. This may result in faster reaction times (Amorim, Isableu, & Jarraya, 2006). While many experts have been looked at, people who practice Tae Kwon Do are not among this group, nor are martial artists in general. It would be beneficial to see how martial artists rotate these objects in order to begin to understand how their motor skills differ from non-practitioners. Spatial ability has been shown to correlate with devotion to science, technology, engineering, and math domains (Wai, Lubinski, & Benbow, 2009), and it would also be advantageous to see if practicing martial arts increases spatial ability skills for people who wish to pursue these fields (Habacha, Molinaro, Tabben, & Lejeune-Poutrain, 2014).

Literature Review

The Beginnings of Mental Rotation

Shepard and Metzler (1971) conducted research in which participants were shown images of three-dimensional block figures. They were given two images and asked whether, when rotated, the two images were congruent or mirror images of each other. In this study, the figures were rotated every 20°. The reaction time increased linearly with angular disparity between the images. There was no difference between rotations in depth versus those made in the picture plane.

Stable Reference Point

A different Shepard and Metzler (1988) investigated whether familiarity with stimuli could affect reaction times during a mental rotation task. One hypothesis was that the more dimensionality the stimuli had, or the more three-dimensional versus two-dimensional it looked, the longer the reaction times would be. In other words, participants would take more time encoding a two-dimensional image into a three-dimensional mental representation rather than a two-dimensional representation. To test this hypothesis, flat polygons and the three-dimensional blocks used in the 1971 study were used as the stimuli, but rotated at 45˚increments. The researchers hypothesized that it would take longer when both images presented were in an unpredictable orientation instead of one image staying the same and the other changing. This may occur because participants do not have a strong enough mental representation of the figure to compare for congruency, so they need to constantly look between the two images to check. If one figure stays in the same orientation throughout the experiment, the participants will develop a better representation of that figure in memory, allowing for faster reaction times (Shepard & Metzler, 1988).

The results showed that participants mentally rotated the images more quickly when one image stayed in the same orientation throughout the duration of the experiment while only the other changed, supporting the hypothesis that keeping one image stationary helps develop a stronger representation in memory. There were more mistakes when the two images were in different orientations each time. Also, the participants had slower reaction times with three-dimensional figures than two-dimensional figures on all trials, supporting their other hypothesis (Shepard & Metzler, 1988).

Familiarity and Training

Tarr and Pinker further investigated the effect that familiarity with stimuli can have on reaction times during mental rotation tasks (Tarr & Pinker, 1989). They had participants memorize a two-dimensional image in three orientations as well as the mirror reflections of these images during training. When the task began, the images the participants learned were present along with new orientations. The reaction times were fastest with the orientations participants had learned in the practice trials. The new orientations were slowest, but the pattern of reaction times suggests the participants may have performed the mental rotations in an unexpected way. Because they already had a mental representation of the image at three different orientations due to extensive prior training (0˚, 45˚, 135˚, and -90˚), they did not need to mentally rotate all the new stimuli to 0˚ to see if it was congruent to the target stimulus or not. Instead, it seems as though the participants took the new stimuli and mentally rotated them to the closest mental representation orientation-wise, shortening reaction time. For example, if an image was presented at -135˚, participants would compare it mentally with the -90˚ image rather than trying to match it to the 0˚ image. This finding shows the large impact training and having mental representations of the stimuli can have on speed of mental rotations.

These findings were supported by work done in 1989 by Baenninger and Newcombe. They performed a meta-analysis looking at gender differences in mental rotation tasks and showed training can decrease gaps in performance. Traditionally, men tend to outperform women in these tasks (Baenninger & Newcombe, 1989). However, this gap in performance began to decrease the more active women were in special activity participation (such as sports or logic games) and spatial ability tasks. When trained, spatial ability test performances were improved for both genders, and the amount of improvement did not differ based on sex.

Complex Stimuli

Familiarity is not the only factor that plays a role in reaction time during a mental rotation task. Bethell-Fox and Shepard (1988) believed that complexity plays a large role when the stimuli were new to participants; the more complex the stimuli, the slower the reaction times. However, with familiarity, Bethell-Fox and Shepard (1988) hypothesized that complexity no longer played a role. One way they believed participants could establish familiarity with stimuli was through practice in the experiment itself. In this experiment, participants were to look at a 3x3 matrix and indicate when they believed they had enough familiarity with it. After hitting a button, they were shown another matrix that was either the same one they had viewed rotated 90˚ or 180˚ clockwise or counterclockwise or another matrix altogether. The participants then had to make the determination and repeat the process. Then in the next experiment, some matrices were reused from experiment one, while others were brought in as the new matrices. The results indicated that stimulus complexity had a strong influence on reaction time at first, and the more complex stimuli took longer for participants to encode. Practice seemed to eliminate these effects. After 250 trials in experiment two, participants gained familiarity with the stimuli. They had faster reaction times with the very complex stimuli they gained familiarity with in experiment one compared to the less complex stimuli that had just been introduced in experiment two. This shows that familiarity plays a large role in mental rotation reaction times.

Expertise

Everyday Stimuli

Amorim, Isableu, and Jarraya (2006) investigated what would happen when participants were asked to rotate stimuli that appear similar to objects used in everyday life. They created stimuli by taking Shepard-Metzler blocks and mapping human-like characteristics onto them. The researchers hypothesized that if the shapes mimicked those that can be embodied, the reaction times would be shorter because the embodiment would help establish reference points in the stimuli. However, if the shapes were in poses that the body could not physically mimic, it would not help, because no embodied processes are at play. Results indicated that participants were able to perform the task faster when a head was added to the Shepard-Metzler blocks. Also, participants were faster at matching images when the human-like shapes were in poses that could be physically mimicked compared to those that were anatomically impossible. Due to the relatively low error rate with human-like stimuli compared to the other stimuli used, the researchers argued human-like stimuli were processed holistically (Amorim, Isableu, & Jarraya, 2006). When viewed, participants' human schema was activated, and they were able to tell which pieces belong where, allowing for some distractions without causing errors. This was not the case when the stimuli were objects such as lamps. Distractions caused more errors, suggesting they were processed in a piecewise fashion.

Whole-Body Experts

Streggeman, Engbert, and Weigelt (2011) compared experts to novices when it came to mental body rotation tasks and mental object rotation tasks. The expert group in this case was composed of athletes who participated in a sport that involved whole-body transformations, such as gymnastics or trampolining, while the novice group was composed of athletes whose sports did not involve movements around different body axes, such as soccer, rowing, and horseback riding. Participants were shown images of a standing human with one arm sticking out and the letter “R.” In the first experiment, they were asked to determine whether the images were the same or different. In the second experiment, participants were asked to make a left-right judgment on which arm was sticking out in the image of the person.

The results showed a linear increase in reaction time with larger angular disparity between the two stimuli, whether bodies or letters, for the first experiment. There was no linear relationship found with the left-right judgment task. There also was no effect of expertise in the same-different judgment task, but expertise played a role in the left-right judgment task. Motor experts had much shorter reaction times than novices in the second experiment (Streggeman, Engbert, & Weigelt, 2011). This suggests that high motor expertise allowed people to shift their egocentric point of view and imagine spatial transformations from different perspectives. However, this study found that motor expertise did not improve performance on mental rotation tasks in general. The researchers also believe novices used the same mental processes when analyzing two images of bodies and trying to determine if they were congruent or not as when they were analyzing objects. Experts may have performed better because they were used to physically rotating their bodies in odd positions during their sports and watching other athletes in their respective fields do the same.

Ozel, Larue, and Molinaro (2004) found similar results in their study. These researchers compared athletes who participate in open-skill activities, athletes who participate in closed-skill activities, and non-athletes. Closed-skill activities are those where the environment is predictable and responses can be planned in advance, such as bodybuilding or archery, while open-skilled activities are those where the environment is unpredictable and variable, such as basketball and Greco-Roman wrestling. Only males participated in this study. The participants had to perform a mental rotation task determining whether or not two three-dimensional Shepard and Metzler blocks were congruent. Results indicated that athletes always outperformed non-athletes, which contradicts the findings of Streggeman, Engbert, and Weigelt (2011) in their experiment determining congruency. While there was not a significant difference between the two sports groups, the data, as the authors stated, were trending toward open-skill athletes performing mental rotation tasks faster than closed-skill. This may be due to the nature of their sports. In open-skill sports, athletes need to always be alert in their ever-changing environment and ready to process new information to act appropriately (Ozel, Larue, & Molinaro, 2004). Closed-skill athletes have the ability to plan moves and procedures out in advance, which means they are not as used to adapting to change. The inability to find solely closed-skill, or solely open-skill, athletes is a valid limitation of the study recognized by the researchers. The researchers made note of the difficulties of finding athletes who solely practice one type or the other.

Although they did not specifically investigate judo, Ozel, Larue, and Molinaro (2004) described it as an open-skill activity. It is vital for judo experts to maintain high body awareness throughout their matches and exercises. Campos, Gonzalez, Dopico, and Iglesias (2002) conducted research showing that judo students do indeed have high levels of imaging capacity. They had intermediate level judo students perform measures of imaging capacity and body image on judo movement skills. Participants imagined themselves doing different activities and rated the intensity of the sensation of movement in each case. They also completed the Body Consciousness Questionnaire. The participants completed judo moves five times each, and motor competence during each movement was assessed. Imaging capacity and haptic movement did not have any effect on judo motor skills, but they did have an effect on body image (Campos, Gonzalez, Dopico, & Iglesias, 2002).

Morreau, Mansy-Dannay, Clerc, and Guerrién (2011) wanted to test even more diverse populations. They believed all fighting sports required a high level of spatial awareness in regard to body movements, and they recruited experts who participated in fencing, wrestling, or judo. These experts were compared to novices and runners, who are considered experts of a sport that does not involve rotations around a body axis, in mental rotation and movement imagery specific tasks (Morreau, Mansy-Dannay, Clerc, & Guerrién, 2011). Results showed that those who participated in combat sports performed mental rotation and movement imagery specific tasks faster than roadrunners. This may be because experts in combat sports have strong mental representations of the different transformations described in the questions, allowing them to more efficiently utilize motor strategies to answer the questions. There did not appear to be a difference on the type of combat sport, but the males performed significantly better than the females on all tasks. In a follow-up study using only wrestlers and runners, the same results were found (Morreau, Mansy-Dannay, Clerc, & Guerrién, 2012).

Embodied Rotations

Ionta, Fourkas, Fiori, and Aglioti (2007) examined the detrimental effects of mentally rotating body images while the participants' bodies were restrained. They had participants complete mental rotation tests using hands and feet as stimuli. In one condition, the participants kept their hands on their knees. In another condition, participants kept their hands behind their back in an unusual posture, with intertwined fingers. The second group took longer to mentally rotate images of hands, but there was no difference in the rotation time for feet. This finding suggests that having the hands in an unnatural position disrupted the participants' body schema, but only with respect to the parts of the body that were in an unusual orientation, which, in this case, were the hands. If the unnatural position of the hands had affected the whole body schema, the second group also would have taken longer with mental rotation of feet, but this was not the case. This finding suggests that that portion of the body schema remained intact, and the participants were able to access it as easily as those without the same restrictions on their hands.

To further investigate if people used their body schema to mentally rotate objects, Jansen and Lehmann (2013) tested a group with a well-developed body schema – gymnasts. They discovered that gymnasts perform these mental rotation tasks even faster if the stimuli did resemble human bodies. They compared soccer players, gymnasts, and non-athletes. Participants completed a mental rotation task involving human and cube figures. They had faster reaction times for the human figures overall, and gymnasts had faster reaction times than non-athletes (Jansen & Lehmann, 2013). With gymnasts, the highest number of items correctly identified occurred for participants who practiced gymnastics 1 – 2 hours a week, while those who practiced 5 hours a week had the most items incorrect, puzzling researchers. For soccer players, the highest number of items correctly identified occurred for those who played soccer 4 hours a week, with the second highest occurring in the 5 hour group. These results seem to show that there is a limit to how much practice is beneficial. Too much practice for the gymnasts may have detrimentally affected their performances on the task. There may not be a linear relationship between amount of experience and performance on mental rotation task, but rather a curvilinear one, though the reason why is not clear.

If participants use their body schema to assist in mental rotation tasks, then a disruption of that schema should hinder the reaction times. Petit and Harris (2005) investigated what would happen if the difference was between stimuli that are anatomically impossible and anatomically possible but not whole bodies. In this experiment, they used hands with thumbs and wrists in anatomically possible and impossible poses and arms in anatomically possible and impossible poses. Petit and Harris believed anatomical limitations would have an effect on reaction times during mental rotation tasks. For stimuli where the thumb was bent back unnaturally, they believed participants would take longer, because the nature of the stimuli would counter their pre-existing body schema. The results supported this hypothesis. The participants made the most errors and took longest with anatomically impossible stimuli. With stimuli that could be embodied and were anatomically possible, the reaction rates were much faster. This finding suggests that participants processed these stimuli holistically, as with the stimuli in the Amorim, Isableu, and Jarraya (2006) study. The speed at which they mentally rotated these stimuli may also be due to familiarity with body parts, especially hands, which are more visible than many other body parts. This explanation, if correct, would support results found by Bethell-Fox and Shepard in 1988. With anatomically correct stimuli, the rate of mental rotation increased linearly with angular disparity, as in previous studies (Petit & Harris, 2005). This pattern was not the case with anatomically incorrect stimuli, as they all displayed slow reaction times despite orientation, supporting the theory that they were all processed in a piecewise fashion. These strange results may be due to the lack of mental representations available for the anatomically impossible stimuli.

Laterality Judgments

This effect is also found when participants had to judge laterality of images (whether the image presented is a "left" image or "right" image, such as a hand) and had their arms in unusual poses (Ionta & Blanke, 2009). Participants had either their right arm or left arm tied behind their back, while the other hand was placed on their knee. They were then asked to judge the laterality of stimuli consisting of images of hands and feet. Right-handed participants displayed slower reaction times when presented with right-sided stimuli while their arms were restrained behind their backs. This delayed reaction time was not evident in left-handed participants with their left arm behind their backs or when the participants had their dominant hand resting on their knee (Ionta & Blanke, 2009). The effect was evident whether participants were able to see their dominant hand or not, as in one experiment the participants' dominant hand, while on their knees, was under a table and thus not visible. Having the participants hold their arms in unnatural positions behind their backs may have disrupted their body schema, which would help explain the slower reaction times in only the affected areas.

Specific-Limb Experts

Dolléans, Hauw, Day, and Saramejane (2011) conducted a meta-analysis investigating the different psychological processes involved during acrobatic performances. The researchers investigated the relationship between performance on a mental rotation task and sports activity with three experimental groups: gymnasts who used mental and physical rotations in their practice, athletes whose activities required very little motor rotation, and non-athletes. Both groups of athletes had faster reaction times than the non-athletes, similar to the findings of Streggeman, Engbert, and Weigelt (Dolléans, Hauw, Day, & Saramejane, 2011). In 2003, Schack showed that gymnasts performed mental rotations when planning out moves and that these rotations were vital to their long-term commitments to their movements (Dolléans, Hauw, Day, & Saramejane, 2011). This finding indicated that the gymnasts may have possessed expertise when it came to mental rotation, especially when the stimuli resembled human bodies.

Jansen was interested in whether expertise in a domain that did not involve full body transformations would transfer to an increase in performance on mental rotation tasks when compared to non-athletes (Jansen, Lehmann, & Van Doren, 2012). The researchers had soccer players and non-athletes perform mental rotation tasks with three-dimensional Shepard-Metzler blocks, human figures, and hybrid human and cube fusion figures. The soccer players outperformed the non-athletes, suggesting they embodied the human-like figures. They even did better with the Shepard-Metzler blocks, contrary to the findings of Streggeman et al. (2011). Interestingly, non-athletes performed fastest with the Shepard-Metzler blocks and slowest with the human figures. The soccer players performed fastest with the figures in body postures and slowest with the Shepard-Metzler blocks (Jansen, Lehmann, & Van Doren, 2012).

Rather than focus on the type of expertise, Habacha, Molinaro, Tabben, and Lejeune-Poutrain (2014) investigated the effect of the stimuli used. More specifically, they investigated whether changing the stimuli to reflect the specific expertise used in one sport will markedly decrease reaction times during mental rotation tasks. In this study, table tennis players, experts with regards to hands, were compared to soccer players. They were right-handed males. The participants were asked to judge laterality of images of hands which were rotated both in-plane and in-depth. Experts were significantly faster at judging laterality of right-handed images rather than left-handed, but there was no significant difference for non-experts. While non-experts were faster at in-depth rotation than planar ones with left-hand and right-hand stimuli, this effect was only found with left-hand stimuli with experts (Habacha, Molinaro, Tabben, & Lejeune-Poutrain, 2014). These patterns mimic those obtained with biomechanical restraints, suggesting participants embodied the rotations to determine laterality. The idea that participants embodied the rotations is supported by participants being faster with right-hand stimuli than left-hand stimuli. Because the table tennis players were right-hand dominant, they also had more mental representations of that hand in different orientations than their other, which may have been transferred to the mental level and can account for their faster reaction times.

Other Types of Expertise

Jansen and Pietsch (2012) wanted to see if education or music training could have beneficial effects similar to those of sports training on performances during mental rotation tasks. They tested college students whose majors were music, education science, or sports, and had them perform a mental rotation task with the three-dimensional Shepard-Metzler blocks, asking whether or not the two images on the screen were congruent (Jansen & Pietsch, 2012). They found that the sports and music students performed better than the education science students. The music and sports students performed about equally as well, which may be explained by their high level of motor competence. Anatomically, the brains of athletes and musicians are markedly different from non-athletes and non-musicians, with athletes and musicians showing more development in areas correlated with motor processing (Jansen & Pietsch, 2012).

In-depth rotations

Habacha et al. sought to answer the question of whether mental rotations of stimuli in depth were recognized more quickly by experts (Habacha, Lejeune-Poutrain, Margas, & Molinaro, 2014). The researchers hypothesized that if stimuli were related to the expertise of the participants, they would be processed faster. They recruited soccer players, handball players, and gymnasts (all males). The researchers created images of a person either hitting a ball in a handball pose or kicking a ball in a soccer pose. These images were then rotated both in-depth and in-plane. Participants were asked to judge laterality during the mental rotation tasks.

Results showed that soccer players and handball players performed the in-depth rotations faster than in-plane rotations and with significantly fewer errors. Gymnasts did not do in-depth rotations faster than in-plane ones, nor did they outperform the other two groups on both types of rotations in regards to time. Soccer players also performed significantly faster for soccer strike images (Habacha, Lejeune-Poutrain, Margas, & Molinaro, 2014). The researchers believe gymnasts did not display a significant difference between in-depth and in-plane rotations because they perform movements around both body axes in a plethora of orientations, even upside-down.

Despite the fact that gymnasts did not mentally rotate the images faster than the other two groups, they had significantly fewer errors. The researchers believe soccer players and handball players may have guessed quickly when they saw the stimuli or used other, less efficient, mental strategies to process the images (Habacha, Lejeune-Poutrain, Margas, & Molinaro, 2014). Another reason the gymnasts may have performed well is that they were very familiar with both arms and legs, so neither stimulus put them at a disadvantage, unlike handball players, who may have been disadvantaged by the images of soccer strikes (Habacha, Lejeune-Poutrain, Margas, & Molinaro, 2014). This finding is consistent with a speed/accuracy trade-off. Because the soccer and handball players may have guessed, they would have responded more quickly than gymnasts, who may have taken extra time to ensure their accuracy.

Are Experts Better than Novices?

Neurological Foundations of Mental Rotation

Using the same stimuli as Petit and Harris (2005), Overney, Michel, Harris, and Pegna (2005) investigated whether the brain processes anatomically incorrect stimuli the same way it processes anatomically correct stimuli. EEG data were collected from scalp electrodes on the participants while they were mentally rotating the different stimuli. The results supported those found by Petit and Harris in 2005 because anatomically possible stimuli took participants, on average, less time than anatomically incorrect stimuli. The reaction times indicated that the participants had such a high level of familiarity with the stimuli that they did not need to rotate it to an arbitrary position marked 0˚ to check whether two images were the same or different. They had enough mental representations of body parts in many different orientations to make the decision quickly and without extra mental exertion (Overney, Michel, Harris, & Pegna, 2005). The mental rotation of body parts caused activation in the left parietal area, while the anatomically incorrect body parts and other stimuli activated other areas. This finding shows physical evidence to suggest differences between experts and novices.

In a similar experiment conducted by Wraga, Shepard, Church, Inati, and Kosslyn (2005), mental rotations of objects were compared to imagined rotations of the participants themselves using an fMRI. The researchers gave participants a three-dimensional Shepard-Metzler block that either had a small “T” on one end of the block or did not. In the condition where the participants had the “T” on the block, they were asked to imagine rotating the block until the “T” on the end was aligned with a “T” next to the shape. In the other condition, participants were asked to imagine rotating themselves to a “T” on the outside of the block. One cube on the Shepard-Metzler block had a face that was textured differently from the others. Once the participants imagined themselves rotated to the “T” on the outside of the block, they were asked if the textured cube was visible or not. The object task activated low-level motor activity, but this activation was absent in the self-rotation task (Wraga, Shepard, Church, Inati, & Kosslyn, 2005). The self-rotation task showed activation in areas associated with complex spatial judgments, suggesting high-level motor activation. Participants also had shorter reaction times and were more accurate in the imagined self-rotation condition than the object rotation condition. Interestingly, participants were most accurate when the angle of rotation was 100˚, which is similar to a major axis of the human body. This finding supports the idea that participants imagined themselves in the rotation task. When the angle of rotation was 65˚ and

135˚, the participants were less accurate and slower. These angles are oblique to the orthogonal axes of the human body, which would make people less familiar with them.

Prior to this experiment, Wraga et al. explored mental rotation using PET (Wraga, Thompson, Alpert, & Kosslyn, 2002). In one condition, participants were asked to mentally rotate images of hands, followed by three-dimensional Shepard-Metzler blocks. In another condition, participants were asked to mentally rotate three-dimensional Shepard-Metzler blocks for two rounds. Area 6 and M1 were activated when mentally rotating Shepard-Metzler blocks only for the group that had first mentally rotated images of hands. These areas were activated during mental rotations of hands. For the other condition that used only mentally rotated Shepard-Metzler blocks, these areas never displayed activation. These findings suggest motor strategies used during imagined body transformations can be transferred to imagined object transformations if primed without the participants' awareness. The objects in the hand-object condition were mentally rotated in an egocentric way, similar to how bodies were rotated, without the participants being instructed to think of the objects differently.

The idea that body parts are mentally rotated differently in the brain than objects is not a new one. In 1998, Kosslyn, Digirolamo, Thompson, and Alpert conducted a study with twelve right-handed males to see how their brains activated differently when mentally rotating images of hands and three-dimensional Shepard-Metzler blocks. Vastly different areas were activated for each type of stimulus. As with past research, hands were mentally rotated more quickly than the Shepard-Metzler blocks (Kosslyn, Digirolamo, Thompson, & Alpert, 1998). The different areas of activation suggest there are at least two ways people mentally rotation images. One method does not rely heavily on motor processes, while the other does.

The Fan Effect

Based on this large body of work, there are clear indications that training in sports domains is related to faster reaction times during mental rotation tasks. However, the relationship between sports expertise and performance on mental rotation tasks may not be linear, as Jansen and Lehmann discovered (2013). Perhaps the Fan Effect can explain the curvilinear relationship between sports expertise and mental rotation tasks (Anderson, 1974).

In his series of experiments, Anderson had participants hear propositions about certain people (such as a hippie, policeman, and sailor), and their locations or physical attributes (Anderson, 1974). For example, one proposition would state that the hippie is in the park, while another would state that the sailor is wearing red. Then he would ask questions about the people, such as whether or not the hippie is wearing red, or if the policeman is in the park. Anderson discovered that the more pieces of information participants had about a person, the longer it took them to recall or verify any one piece of information. He called this effect the Fan Effect. When people learned information about one item, those pieces of information were organized as fans centered on that item. When asked to verify a piece of information, they had to mentally go through all the pieces of information, or fans, they had to ensure they were not missing something. The more fans they had, the longer it took to do this process, as his results indicated.

When experts perform mental rotation tasks with familiar stimuli, they oftentimes have a vast mental storage of different orientations of the stimuli. During a laterality task, participants need to mentally sift through all the representations of the stimuli to see if the target stimulus matches their preexisting mental representations. Similar to the Fan Effect, the more representations they have in memory, the longer it may take them to do this. This may be why

Jansen and Lehmann found an increase in reaction time with the highest levels of expertise (2013).

In 1978, Anderson and Paulson did a series of experiments showing that the Fan Effect did appear to occur with visual stimuli as well, supporting this theory. In these experiments, they showed participants images of faces and associated the faces with professions (Anderson & Paulson, 1978). The researchers wanted to see if the participants would take longer identifying faces when they shared common features with many other faces rather than ones that were relatively unique. For example, the firefighter might have the same eyes, mouth, and ears as the sailor, but they may have different noses and hair. The hypothesis was that it would take longer to differentiate these two than a firefighter and a policeman who only shared the same eyes. This extra time would mean the identification of one face that shared many features with others should take longer. The results supported the hypothesis, suggesting that the Fan Effect occurs with visual information as well as verbal. Hands and body images share many common features with each other, even at different orientations. The more mental representations participants have, the longer it may take to verify any one image in a mental rotation task.

Research Objective

The aim of this study was to expand in areas Habacha, Lejeune-Poutrain, Margas, and Molinaro (2014) did not, while testing a different type of expertise at the same time. Although their study was the first to truly do in-depth rotations at different angular intervals, this one involved in-depth and in-plane rotations to see whether the finding that in-depth rotations were completed more quickly could be replicated. Instead of using handball players, soccer players, and gymnasts, this study investigated the mental rotation of three-dimensional Shepard-Metzler blocks, whole body figures in everyday poses, and whole body figures in martial arts poses with martial arts experts and novices. The number of errors experts made as opposed to novices was compared. This study also included both males and females, while Habacha et al.'s study included only males (2014).

One hypothesis is that experts will perform the mental rotations faster than novices. Experts may perform the rotations faster than novices, as the Habacha et al.'s study has shown (2014). However, they may perform slower due to interference in their long-term memory as explained by the Fan Effect (Anderson, 1974). Martial artists have a unique advantage over other types of experts. During their training, students learn the forms and techniques by observing an instructor in the front of a room performing the mirror reflection. This type of teaching may increase the speed at which experts recognize mirror reflections of stimuli due to the increased exposure.

A second hypothesis is that all participants will mentally rotate the in-depth figures faster than the in-plane ones. This hypothesis is in line with the results found by Habacha, Lejeune-Poutrain, Margas, and Molinaro (2014). It would also make sense with martial artists, because many of the poses and stances require them to move their whole body in the depth plane. This experience would provide them with a greater number of mental representations of in-depth rotations as compared to in-plane, which may result in faster mental rotation reaction times (Overney, Michel, Harris, & Pegna, 2005). Another hypothesis is that experts will make fewer errors than novices due to their more well-developed body schema, as this has been shown to be the case in previous research (Amorim, Isableu, & Jarraya, 2006).

Method

Participants

Participants were collected from an online recruiting system used at the University of Central Florida and from the Tae Kwon Do club on Campus. There were initially 51 participants, but 20 were not included in the analyses because they finished the task with less than 80% accuracy. There were initially 25 experts and 26 novices, with 29 males and 22 females. The final 31 participants were composed of 16 experts and 15 novices, with an age range of 18 to 26 years old (M = 18.78, SD = 1.82). Expertise was defined as having at least a first degree black belt or equivalent rank or three and a half years of experience in martial arts (Bedon & Howard, 1992). There were 11 females and 20 males. Participants were given the option to receive class credit for participation or $10 for every hour of participation.

Stimuli

Participants used the computer program SuperLab to perform all mental rotation tasks. The stimuli consisted of three-dimensional Shepard-Metzler blocks rotated in-plane and in-depth, Tae Kwon Do figures rotated both in-plane and in-depth, and whole body images in everyday poses rotated in-plane and in-depth. The human figures were either posed holding their shoulder, in an elbow strike pose, or in a front kick pose. The human figures were obtained from posemaniacs.com (Takayuki, 2015), and the images were altered to fit the parameters of the SuperLab software using Microsoft PowerPoint, Microsoft Paint, and GIMP. Participants also completed a demographics survey on Qualtrics. The demographics survey included information about expertise in other sports domain, such as questions about how many other sports the participants may have participated in and the duration, as well as perceived expertise in the other sports or martial arts they have participated in.

Procedure

Participants were brought into a quiet room and seated at a desktop. They then went through a practice task involving mental rotations of the letter "L" and "R" to understand how to complete a mental rotation task. The goal was to determine if, when rotated, the two images presented simultaneously on the screen were congruent or mirror images of each other. The image on the left was always in the same orientation the whole time (0˚), while the one on the right was transformed. The "J" and "F" keys on the keyboard had blue and red tape on them respectively. Participants pressed the "F" key if the images were different and the "J" key if images were the same. Once the practice task was complete, participants completed the real task. Afterward, they were given the demographics survey.

Results

Percent Correct

Participants who scored lower than 80% accuracy were excluded from the analysis. An independent samples t-test indicated there was no significant difference between experts and novices in terms of percent correct (M = 0.89, SD =0.04; $t(29) = 0.27$, $p = 0.79$). Those excluded (M =0.64, SD = 0.10) answered significantly more correct than if they had answered by chance ($t(19) = 6.26$, $p = 0.00$). An independent samples t-test indicated there was no significant difference between experts and novices in terms of percent correct when the excluded participants were included (t(49) = 0.83, p = 0.406).

Reaction Time

A 2 (expertise: expert or novice) x 4 (stimulus type: Shepard-Metzler, holding shoulder pose, elbow strike, and front kick) x 2 (dimension: two-dimension or three-dimension) mixed analysis of variance (ANOVA) was conducted on the data, where expertise was between-subjects and the other variables were within. This analysis yielded a dimension by expertise interaction ($F(1,28) = 8.78$, $p = 0.006$). In this case, for experts, two-dimensional images (M = 6.36, SD = 1.37) were rotated more quickly than three-dimensional images (M = 10.27, SD = 1.73). However, novices exhibited the opposite pattern. Three-dimensional images (M = 7.30, SD = 1.73) were rotated more quickly than two-dimensional images (M = 9.81, SD = 1.37). This effect is shown in Figure 1. To further investigate whether there was a significant difference in reaction times between experts and novice, an independent samples t-test was conducted. The results indicate that with two-dimensional stimuli, the difference in reaction time between experts (*M* = 6.36, *SD* = 4.18) and novices (*M* = 10.27, *SD* = 8.19) was not significant ($t(28) = -1.78$, $p = 0.086$). With three-dimensional stimuli, the difference in reaction time between experts (*M* = 10.27, *SD* = 8.19) and novices (*M* = 7.30, *SD* = 4.78) was not significant ($t(28) = 1.21$, $p = 0.24$) either.

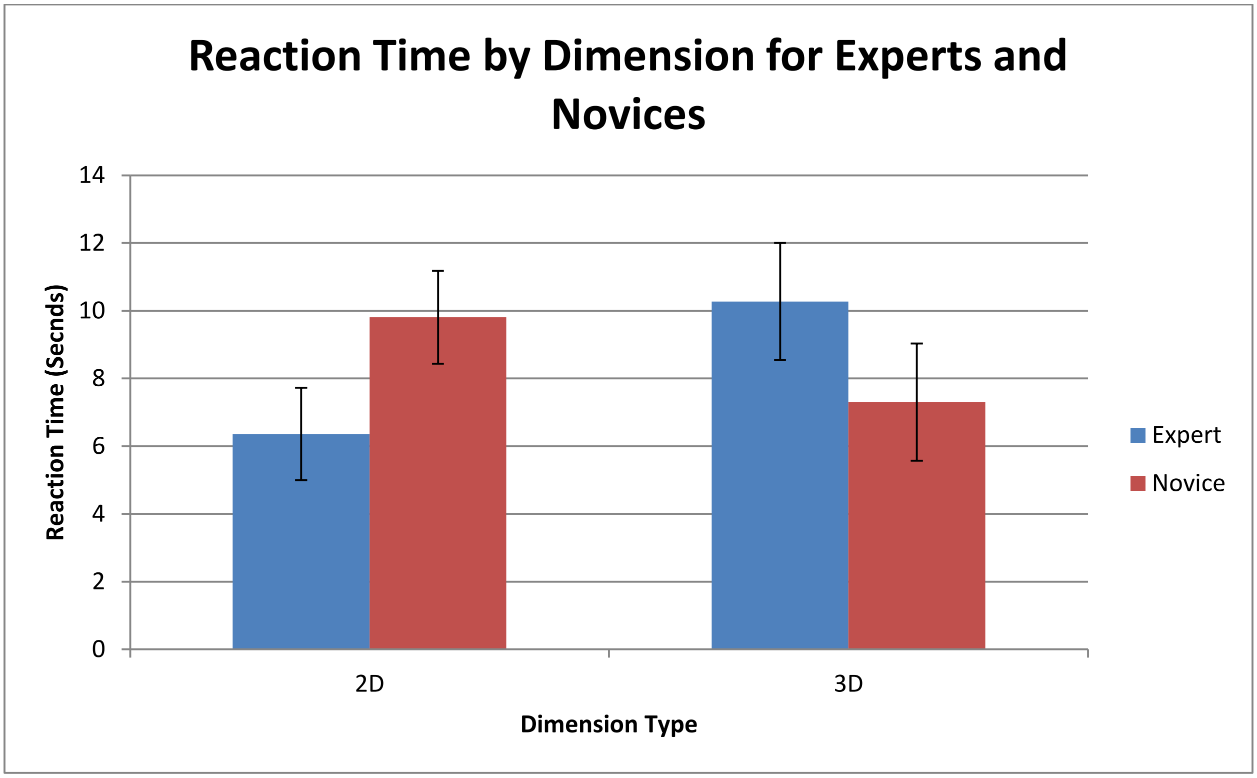


Figure 1: Graph showing interaction between expertise and dimension.

Three paired-samples t-tests were conducted to investigate reaction time by expertise for two-dimensional stimuli and three-dimensional stimuli. There was no significant difference in reaction time between the dimensions overall for all the participants or for only the novices (*p* = 0.569, 0.148). However, there was a significant difference with experts between the two - dimensional stimuli (*M* = 6.36, *SD* = 4.18) and the three-dimensional stimuli (*M* = 10.27, *SD* =

8.19; *t*(14) = -2.76, *p* = 0.015). Experts were significantly faster at mentally rotating the two-dimensional stimuli. The results are shown in Figure 2.

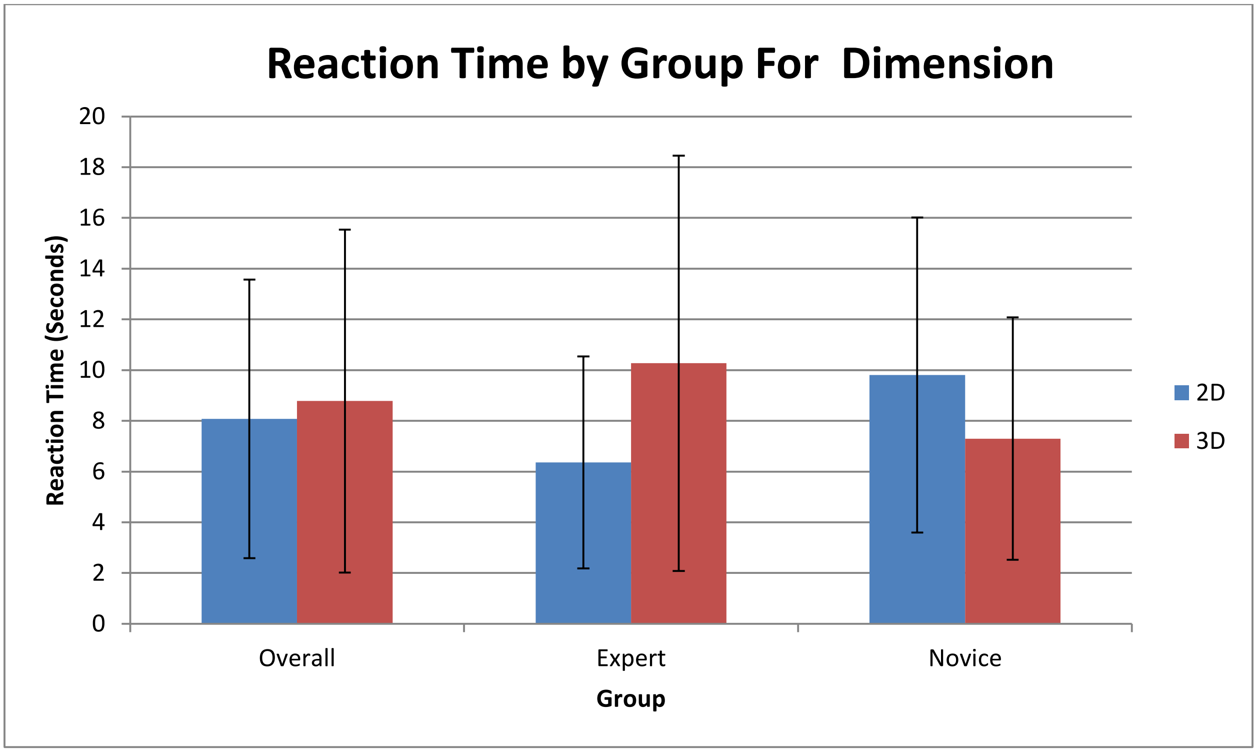


Figure 2: Graph showing reaction time by group for each dimension

The ANOVA also indicated a significant interaction (*F*(3, 26), *p* = 0.014) between stimulus type and dimension. Paired-samples t-tests were conducted on dimension for each stimulus. This analysis revealed that for the front kick stimuli, three-dimensional rotations (*M* = 8.25, *SD* = 6.49) were completed significantly more quickly than two-dimensional rotations (*M* = 11.38, *SD* = 7.57; *t*(30) = 2.32, *p* = 0.014). For the Shepard-Metzler stimuli, two-dimensional stimuli (*M* = 4.20, *SD* = 7.97) were mentally rotated more quickly than three-dimensional stimuli (*M* = 11.63, *SD* = 18.35; *t*(30) = -2.51, *p* = 0.039). For the elbow strike and holding shoulder pose stimuli, there were no significant effects of dimension (p = 0.59, 0.53). The results of dimension by stimulus type are shown below in Figure 3.

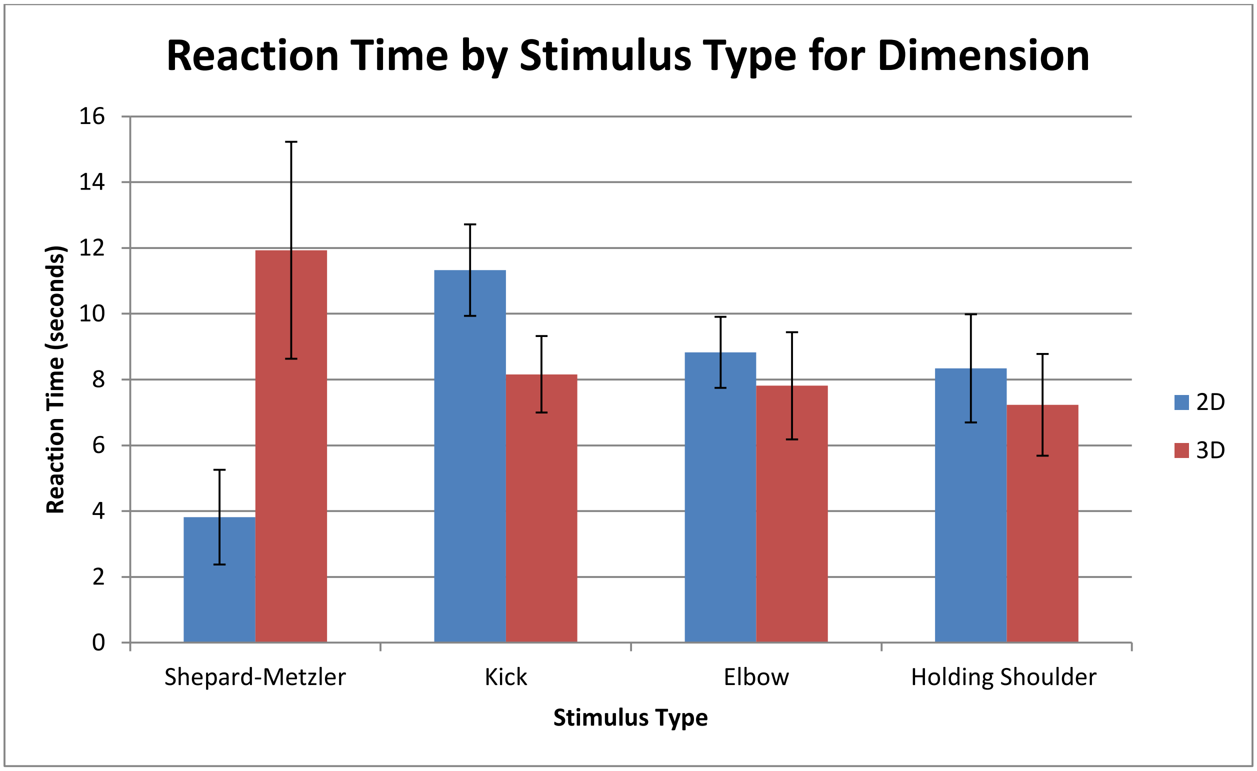


Figure 3: Graph showing reaction time by stimulus type for each dimension

A post-hoc paired-samples t-test was conducted to determine if there was a significant difference between stimuli type by expertise, which would indicate if some stimuli were more easily rotated in-depth rather than in-plane or vice versa. The results showed that the experts (M = 7.89, SD = 1.51) were overall significantly faster than the novices (M = 11.61, SD = 1.51; $t(30)$ = 2.316, p = 0.028) when mentally rotating the front kick stimuli. With the Shepard-Metzler stimuli, the novices (M = 5.61, SD = 2.76) were significantly faster overall than the experts (M = 10.15, SD = 2.76; $t(30)$ = -2.153, p = 0.039). There were no significant differences between experts and novices with the elbow strike stimuli or the holding shoulder pose stimuli (*p* = 0.589, 0.528). These findings are shown below in Figure 4.

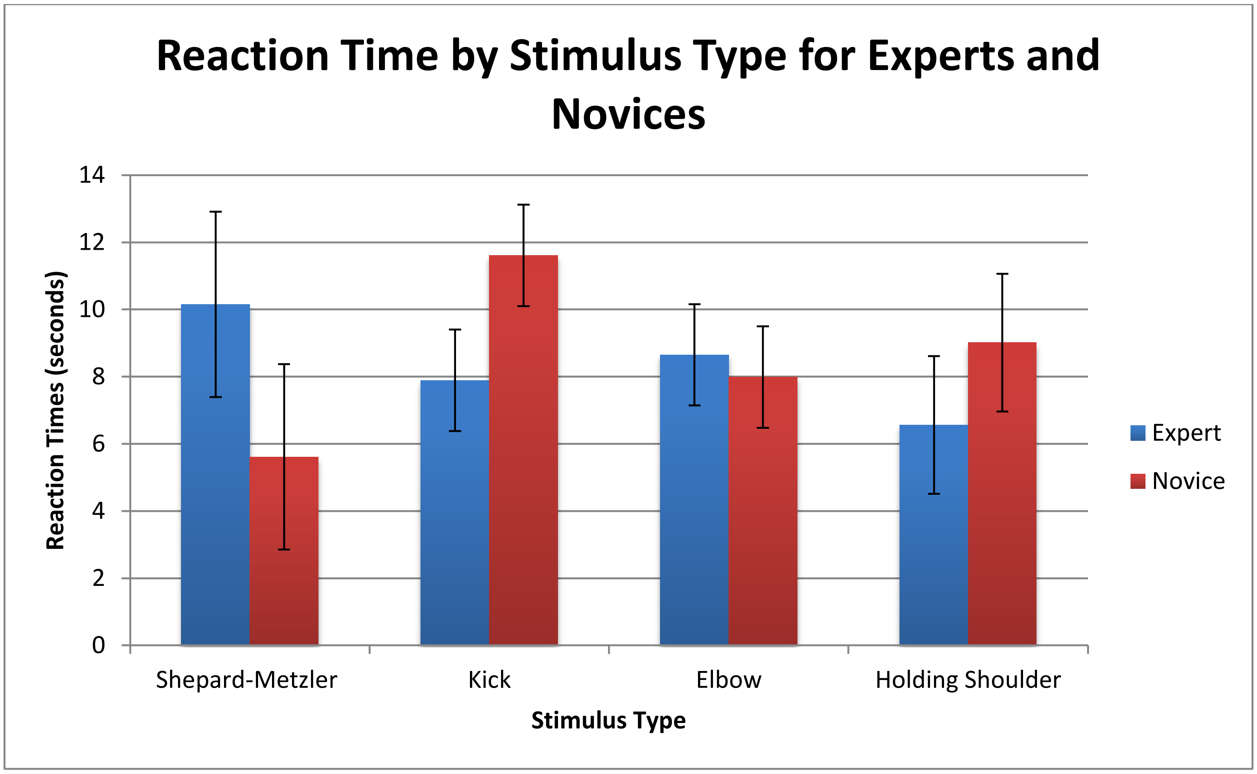


Figure 4: Graph showing reaction time by stimulus type for experts and novices

Discussion

Are Experts Faster Than Novices?

The first hypothesis that experts would mentally rotate the stimuli faster than novices was partially supported by the data. Experts were faster with the front kick stimuli, but they were slower with the Shepard-Metzler stimuli. The results concerning the front kick stimuli support previous findings that familiarity with stimuli plays a role in reaction time (Tarr & Pinker, 1989). Experts in martial arts would all have much experience with a front kick, as there is at least one variation in almost every style of martial arts. With increased familiarity, the experts may have recognized the images more quickly, which helped them determine if the two images they were presented with were the same or mirror reflections of each other. The novices did not have this experience, so they would not have any type of advantage when mentally rotating these stimuli.

There was not a significant difference in terms of expertise with the holding shoulder pose images, which was in line with previous research. Because humans have more familiarity with human bodies than Shepard-Metzler blocks, they often exhibit faster reaction times when the stimuli resemble humans (Amorim, Isableu, & Jarraya, 2006). Experts should not have more experience with neutral body poses than novices; the experience should be equal. As a result, the two groups should be equal and show the same performance due to the equal familiarity (Tarr & Pinker, 1989).

The reaction times with the elbow strike images do not indicate that expertise played a role. If it had, the experts should have mentally rotated the images more quickly than the novices due to the increased familiarity. However, this does not appear to be the case. Elbow strikes are not a movement seen solely in martial arts. Many other sports, such as football, involve elbow movement of some sort. Both the experts and novices may have had equal amounts of experience with the stimuli, as with the holding shoulder pose. Alternatively, participants may have latched on to the elbow as a focal point, allowing them to judge whether or not the images were the same or mirror reflections more quickly (Wraga, Shepard, Church, Inati, & Kosslyn, 2005).

In regard to the Shepard-Metzler blocks, it was surprising that experts were slower overall at mentally rotating the images than novices. This finding contradicts previous findings with gymnasts and judo practitioners (Habacha, Molinaro, Tabben, & Lejeune-Poutrain, 2014). However, it supports previous research that concluded expertise did not play a role when the stimuli were not familiar (Streggeman, Engbert, & Weigelt, 2011). There may have been a speed/accuracy trade-off. The experts may have wanted to ensure they were accurate before making a decision, while the novices may have guessed more, resulting in overall faster reaction times. Because the sample size was not large, individual differences may have played a role. All of the novices participated in the study for class credit in a psychology course, but some of the experts were recruited from a campus Tae Kwon Do club and had never taken a psychology course before. The novices may have had prior experience with the Shepard-Metzler blocks if they had taken a cognitive or basic learning course. This experience may have eliminated the effects of complexity, allowing the novices to mentally rotate the blocks more quickly than the experts (Bethell-Fox & Shepard, 1988).

The difference in reaction times cannot be attributed to differing amount of accuracies between the groups. Analyses did not support the hypothesis that experts would be more accurate than novices. The two groups were not significantly different from one another.

Rotations In-Depth

Examining the Stimuli Overall

The second hypothesis investigated whether all the participants would be able to mentally rotate three-dimensional images more quickly than two-dimensional ones in an effort to validate previous findings (Habacha, Molinaro, Tabben, & Lejeuene-Poutrain, 2014). This was partially supported by the data. Overall, participants mentally rotated two-dimensional Shepard-Metzler blocks more quickly than the three-dimensional images. However, the opposite trend was seen with the kick pose images; participants were faster with the three-dimensional images. There was not a significant difference between dimensions for the elbow strike and holding shoulder pose images. When the reaction times for all two-dimensional and three-dimensional rotations were averaged (as shown in Figure 2), experts were faster with two-dimensional stimuli than three-dimensional stimuli, while novices were not significantly faster with either two-dimensional or three-dimensional stimuli.

In past research, participants mentally rotated three-dimensional images more quickly because they embodied the stimuli (Habacha, Molinaro, Tabben, & Lejeune-Poutrain, 2014). The participants in this study mentally rotated the in-depth figures faster than the planar ones, suggesting they also embodied the stimuli. However, this was not seen with the Shepard-Metzler blocks because they do not have any human characteristics to aid in the embodiment (Amorim, Isableu, & Jarraya, 2006). Without embodying the stimuli, participants may have had a more difficult time imagining the rotations in-depth with such abstract figures. The Shepard-Metzler blocks are not directly comparable to the body stimuli either, which may be a confounding variable. Although they were described as rotated three-dimensionally, the stimuli are actually rotated in both two and three dimensions, as the three-dimensional stimuli were presented in a tilted position when compared to the two-dimensional stimuli.

There was not a significant difference with the holding shoulder or elbow strike poses. Because these two poses are not strictly martial arts poses, all the participants may have been able to embody them with an equal amount of proficiency. This would result in similar reaction times for both experts and novices. Participants also may have focused on the elbow and rotated the image piecewise rather than holistically (Amorim, Isableu, & Jarraya, 2006). The front kick pose seems to be more complicated. In the 0˚ rotation, the leg that is performing the kick cannot be used as a focal point because it blends in with the rest of the body. If the image was presented at another angle where the leg could be distinguished from the body as the elbow was, the participants may have rotated the image in a piecewise fashion, which may eliminate the reaction time differences between experts and novices. The front kick pose may have been seen as threatening as well. Participants may have been startled by the image of an overly muscular man kicking toward the screen. Experts, who are trained to respond quickly in these types of threatening situations, may have responded more quickly than novices, who may have been too startled to know how to initially respond.

Examining the Differences between Experts and Novices

Interestingly, experts were significantly faster at rotating objects in the two-dimensional plane, while novices were faster at rotations in-depth. Although this finding counters those of previous research, it is not entirely unexpected (Habacha, Molinaro, Tabben, & Lejeune-Poutrain, 2014). As previously mentioned, the Fan Effect may play a role with the differences seen between experts and novices specifically (Anderson, 1974). Experts are the ones who would have the larger number of mental representations of martial arts poses, which would delay their decision making process. Novices would not encounter this delay and may mentally rotate martial arts poses in-depth more quickly as a result. Because experts have familiarity with the subject matter, the complexity of the images would no longer contribute to the rotation speeds when it comes to the two-dimensional rotations (Bethell-Fox & Shepard, 1988). The experts would not be trying to embody the planar images because they can quickly determine the poses are unrealistic and unnatural (Petit & Harris, 2005). These results may be caused by a speed/accuracy trade-off as well. The experts may have felt a need to complete the task accurately in order to prove their expertise. The novices may have guessed more, which would have resulted in faster reaction times.

The experts also had the unique experience of watching mirror reflections of various martial arts poses while training. Instructors teach students by mirroring forms in the front of the room, and there are often many mirrors in martial arts studios. This would provide experts with many opportunities to study mirror reflections of certain moves and poses, adding to their mental representations of martial arts. The fitness level of the participants may have also played a role. The experts may have been more physically fit due to their martial arts experience. This difference could affect reaction time. Experts may have been more interested in the stimuli as well. Because the body figures did not have skin, participants could see which muscles were engaged in the various poses. The experts may have been interested to see how this muscle activation related to their own bodies, and this extra interest may have delayed their reaction times.

Limitations

This study is the first in an ongoing series designed to investigate the effects of expertise on mental rotation reaction times. In future iterations, some concerns need to be addressed. The sample size was small at 31 participants. More participants should be recruited to eliminate individual differences between groups and increase statistical power. Testing different age ranges may be beneficial as well. Although cognitive abilities decline after the age of 39 (Bailey & Sims, 2014), these participants were mostly in their teens with a few in their 20s. A larger age range will increase ecological validity. Similarly, testing various populations besides only a university one will also increase ecological validity.

One problem encountered during this study involved participant recruitment. Despite a financial incentive, students from various Tae Kwon Do schools were not interested in participating in the study. In order to increase recruitment, the study was opened to all disciplines of martial arts. This presented difficulty, as it was unknown whether the participants who claimed to be experts actually were experts. There was no way to verify the experts were honest about their experience. There was also no way of knowing whether or not the participants were actively practicing martial arts. The benefits of familiarity with expertise may weaken over time as the expertise fades. If some experts had practiced martial arts over ten years ago, they may not have been able to recognize martial arts poses as quickly as currently active practitioners.

Additional questions need to be added to the demographics questionnaire in the future. Participants should be asked about video game experience and general fitness level, as these factors may affect reaction time. The stimuli look similar to certain dance poses, so dance expertise should be measured. Dance experts may be able to embody the stimuli or compare the images to mental representations of dance moves, affecting their reaction times. Also, participants should be asked whether or not they are currently practicing martial arts, and what age they were when they began and ended.

The type of stimuli used also may have presented an issue. Some participants may have found the stimuli very unnerving due to the lack of skin and exposure of muscle. A separate study should be conducted to test whether or not participants are generally comfortable with the images. If not, new stimuli will need to be used.

Many participants voiced concern regarding the past definition of expertise. They felt that three and a half years were not sufficient to define a practitioner as an expert. Perhaps more research should investigate whether this definition truly holds up. If it does not, the participants in the current study may have been improperly grouped, which may explain the lack of support for some of the hypotheses.

Future research should examine only one discipline of martial arts, such as strictly Tae Kwon Do. Past practitioners and current ones should also be tested separately to examine whether the fading expertise negatively impacts the benefits of familiarity with stimuli. Some participants voiced confusion concerning the instructions. They may need to be modified for future studies.

Conclusion

Mental rotation research has important implications for any company or entity that trains its employees. If cognitive abilities can be transferred across domains, a more generalized approach may be utilized in training programs. This can help eliminate expensive redundancies sometimes found in these programs.

This study does not support that expertise can be transferred across domains though. The experts never outperformed the novices when the stimuli were Shepard-Metzler blocks, as has been seen in previous research (Sims & Mayer, 2002). This suggests their expertise extended solely to martial arts. Once the stimuli changed, the effects were gone. This is consistent with the idea that familiarity assists during mental rotation tasks (Bethell-Fox & Shepard, 1988). Once the familiarity is gone, there is no advantage between groups. However, this effect may be strictly limited to martial arts. There may be a type of expertise that is transferrable across domains. Future research needs to be conducted in order to answer the question of whether any expertise is transferrable across domains.

Appendix

IRB Outcome Letters

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Valerie K. Sims** and Co-PI: **Michael E. Torres**

Date: **July 13, 2015**

Dear Researcher:

On 07/13/2015, the IRB approved the following human participant research until 07/12/2016 inclusive:

Type of Review:	UCF Initial Review Submission Form
Project Title:	Mental Rotation with Martial Arts Experts
Investigator:	Valerie K Sims
IRB Number:	SBE-15-11269
Funding Agency:	
Grant Title:	
Research ID:	N/A

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

If continuing review approval is not granted before the expiration date of 07/12/2016, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

All data, including signed consent forms if applicable, must be retained and secured per protocol for a minimum of five years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained and secured per protocol. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Joanne Muratori

Signature applied by Joanne Muratori on 07/13/2015 04:14:23 PM EDT

IRB manager

University of Central Florida

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Valerie K. Sims** and Co-PI: **Michael E. Torres**

Date: **October 23, 2015**

Dear Researcher:

On 10/23/2015, the IRB approved the following minor modifications to human participant research until 07/12/2016 inclusive:

Type of Review:	IRB Addendum and Modification Request Form
Modification Type:	To enhance recruitment, rather than use the term "Tae Kwon Do," the term "Martial Arts" will be used. In addition, a recruitment flyer will be used on campus and other recruitment methods such as e-mail, social media, and the Internet will be used as well. Study participants will be offered the choice of receiving 1.0 SONA credit instead of monetary compensation. A revised Informed Consent has been approved for use and the recruitment flyer was uploaded in iRIS.
Project Title:	Mental Rotation with Martial Arts Experts
Investigator:	Valerie K Sims
IRB Number:	SBE-15-11269
Funding Agency:	
Grant Title:	
Research ID:	N/A

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

If continuing review approval is not granted before the expiration date of 07/12/2016, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

All data, including signed consent forms if applicable, must be retained and secured per protocol for a minimum of five years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained and secured per protocol. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 10/23/2015 11:16:37 AM EDT

IRB Manager

Demographics Survey

Q1 What is your age?

Q2 What is your race?

- Hispanic or Latino (1)
- White (Non-Hispanic) (2)
- Black or African American (Non-Hispanic) (3)
- Asian (4)
- American Indian or Native Alaskan (5)
- Native Hawaiian or Other Pacific Islander (6)

Q8 Do you participate in Tae Kwon Do?

- Yes (1)
- No (2)

Answer If Do you participate in Tae Kwon Do? Yes Is Selected

Q6 How many years have you been practicing Tae Kwon Do?

Answer If Do you participate in Tae Kwon Do? Yes Is Selected

Q7 What rank are you in Tae Kwon Do?

Answer If Do you participate in Tae Kwon Do? Yes Is Selected

Q9 How would you rank your expertise on a scale of 1 to 5 (1 being novice, 5 being expert)?

- ❍ 1 (1)
- ❍ 2 (2)
- ❍ 3 (3)
- ❍ 4 (4)
- ❍ 5 (5)

Q12 Do you participate in other martial arts besides Tae Kwon Do?

- ❍ Yes (1)
- ❍ No (2)

Answer If Do you participate in other martial arts besides Tae Kwon Do? Yes Is Selected

Q13 Please list them below:

Answer If Do you participate in other martial arts besides Tae Kwon Do? Yes Is Selected

Q14 How would you rank your expertise on a scale of 1 to 5 (1 being novice, 5 being expert)?

- 1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 (5)

Answer If Do you participate in Tae Kwon Do? Yes Is Selected

Q3 Do you participate in any other sports besides Tae Kwon Do?

- Yes (1)
- No (2)

Answer If Do you participate in any other sports besides Tae Kwon Do? Yes Is Selected

Q4 Please list them below:

Answer If Do you participate in any other sports besides Tae Kwon Do? Yes Is Selected

Q5 How long have you been practicing these sports?

Answer If Do you participate in any other sports besides Tae Kwon Do? Yes Is Selected

Q20 How would your rank your expertise on a scale of 1 to 5 (1 being novice, 5 being expert)

- 1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 (5)

Q10 What is your occupation?

Q11 What is your highest level of education?

- Less than high school (1)
- High school diploma or equivalent (2)
- Some college, no degree (3)
- Post-secondary, non-degree award (4)
- Associate's degree (5)
- Bachelor's degree (6)
- Master's degree (7)
- Doctoral or professional degree (8)

Q15 Have you worked in, are currently working in, or are interested in working in the science, technology, engineering, or mathematics fields?

- Yes (1)
- No (2)

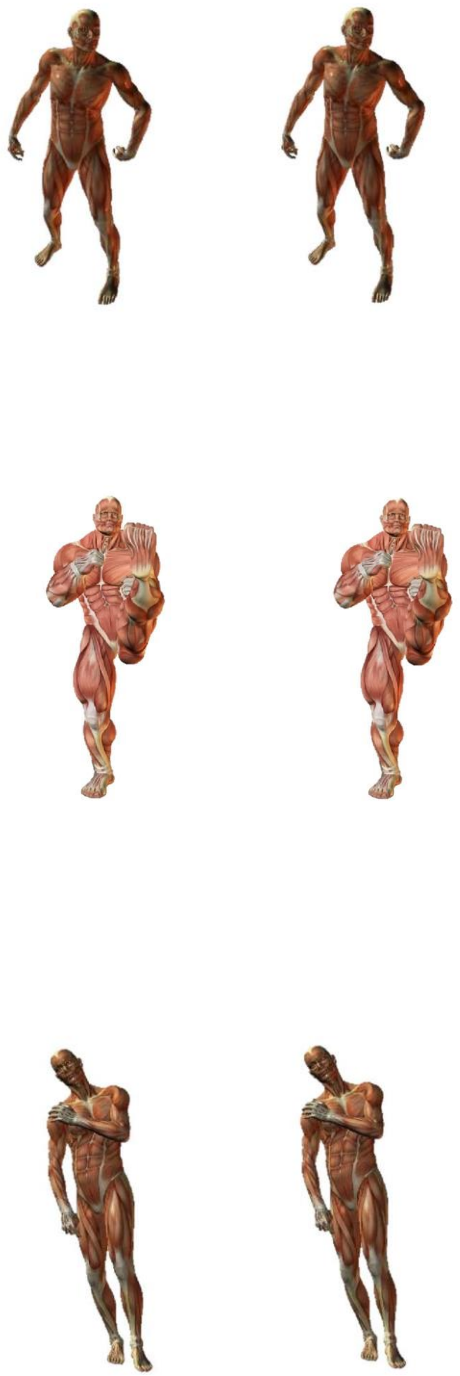
Answer If Have you worked in, are currently working in, or are interested in working in the science, technology, engineering, or mathematics fields? Yes Is Selected

Q21 Which field specifically?

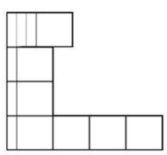
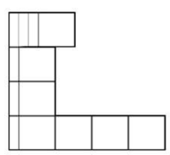
- Science (1)
- Technology (2)
- Engineering (3)
- Math (4)

Q19 What is your participant number?

Stimuli Samples





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