Influence of Task and Tool Characteristics on Scissor Skills in Typical Adults

Anita Witt Mitchell, Carmen Hampton, Mistie Hanks, Chelsea Miller, Natalie Ray

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- motor skills
- movement
- psychomotor performance
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- tool use behavior

To clarify expectations for mature cutting skills and investigate the influences of cutting task and scissor type, we videotaped 60 typical adults cutting three shapes with two different types of scissors. The videotapes were reviewed, and 38 aspects of grasp and cutting motions were rated. Percentages of participants who used a particular grip or cutting motion for each shape with each scissor type were reported and compared. Findings included variations in grasp that depended on the scissor type used and variations in cutting motions that depended on the shape being cut. Improved understanding of mature scissor skills and the effect of variations in the cutting task and scissor type used will allow more effective assessment of and intervention for children and adults with cutting difficulties. Specific implications for practice are discussed.


Tools have been defined as implements used to accomplish tasks (Connolly & Dalgleish, 1989). They facilitate achievement of activities and goals that, in some cases, would otherwise be unattainable. Tool use is a fundamental aspect of human daily life. Examples include spoons and toothbrushes used for self-care, pencils used in school and work settings, and bats and pool cues used in play and leisure. Considering the prominence of tools in daily life, the development of tool use is a concern for occupational therapists.

In this research study, we sought to add to the body of knowledge regarding the mature grasp and movement patterns used for one particular tool, scissors. Little research has been published delineating the characteristics of mature scissor skills, although cutting is a skill commonly practiced in school and in everyday life. In addition, tool and task characteristics that could influence scissor grasp and cutting motions have not been investigated to date. Increased understanding of scissor skills could assist therapists as they assess and treat children and adults with delays or deficits in cutting skills. Specifically, our purpose was to describe scissor grasps and cutting motions used by typical adults and to compare typical adults’ scissor grasps and cutting motions when different types of scissors are used and different shapes are cut.

Review of the Literature

Dynamic Systems View of Tool Use

Tool use is a complex phenomenon that depends on the interaction of many different systems. These systems include person-related systems such as the cognitive system (Connolly & Dalgleish, 1989), the sensory–perceptual system (Schwartz & Reilly, 1981), and the motor system (Ratcliffe, Concha, &
Franzsen, 2007) as well as task variables such as the specific type of tool used (Schwartz & Reilly, 1981), the positioning of materials (Yakimishyn & Magill-Evans, 2002), and the goal of the task itself. The larger social, cultural, temporal, and physical contexts of the task are also factors. Tool use presents several motor problems that must be solved on the basis of these systems’ interaction (Connolly & Dalgleish, 1989). The problems posed by tool use could be solved in many ways, considering the different systems and potential interactions that may vary during skilled tool use.

Dynamic Systems Theory (Kamm, Thelen, & Jensen, 1990; Thelen, 1995) proposes that, from among the many available problem-solving strategies, people choose those that are effective and require minimal energy expenditure. These strategies are known as attractor states. As a particular strategy is practiced, it is used more consistently (Connolly & Dalgleish, 1989; Ratcliffe et al., 2007). With practice, strategies also become flexible, allowing the person to respond to changing environmental or task conditions. For example, Ratcliffe et al. (2007) found that scissor grips and motor patterns changed in response to the increasing difficulty of the shapes children were asked to cut. Yakimishyn and Magill-Evans (2002) also found that maturity of grip changed in response to the varying sizes of writing implements. Thus, practice facilitates adaptation to the changing nature of tasks and the tools used to perform them (Kamm et al., 1990; Thelen, 1995).

According to Dynamic Systems Theory, even small changes in one or a few systems may result in a significant modification in the way a problem is solved. These changes in strategies are referred to as phase shifts, and the variables that result in the reorganization are control parameters (Kamm et al., 1990; Thelen, 1995). As illustrated in Yakimishyn and Magill-Evans’s (2002) study, even minor task characteristics, such as the orientation of the presented tool, can result in a phase shift. During development, changes occur in many of the systems involved in tool use, making it difficult to identify the control parameters responsible for phase shifts. The challenge for researchers is to design studies to examine the complex interactions of various systems involved in tool use. The interaction of two or more changing control parameters may be what induces phase shifts rather than a change in one system alone.

Development of mature, efficient grasp patterns (i.e., attractor states) for specific tools is an important step in the skilled use of any implement. The type of grasp may be dictated by the shape and structure of the tool; however, many tools allow for variation in the type of grasp used for their manipulation, and a variety of grasps may allow for effective, efficient use of the tool (Connolly & Dalgleish, 1989; Yakimishyn & Magill-Evans, 2002). Bergmann (1990), for example, found that the traditionally accepted pencil grip (i.e., the dynamic tripod) was used by most typical adults in her study, but a second grasp (i.e., the lateral tripod) was also used by a relatively large number of the participants, with no indication that use of this grip was detrimental. This study provides a reminder of the need to challenge assumptions about traditionally accepted grasp patterns, particularly when the age of emergence of mature patterns is not clear and the mature patterns themselves have not been clearly defined by research, as is the case with scissors.

Research has contributed to the understanding of the development of tool use, but much has yet to be discovered and clarified about the development of skilled use of specific tools. Assuming that most adults without disability will demonstrate attractor states for skilled tool use, research examining these skills in adults will likely prove informative. Currently, the literature has gaps related to scissor skills. With this study, we sought to add to the body of knowledge related to mature grasp and movement patterns used for cutting with scissors.

**Task Variables Affecting Tool Use**

The emergence of skilled tool use involves development of attractor states as well as the ability to choose and apply those strategies effectively on the basis of the maturity of the involved person-related systems, task constraints, and salient contextual variables. Schwartz and Reilly (1981) demonstrated how person-related and task systems can influence tool use. They studied children’s use of tools with different lengths and weights and found evidence that the participants were able to use sensory feedback to accurately adjust the position of their tool-using limbs in space and perform the intended actions. Schwartz and Reilly proposed that the children incorporated the tool as part of their body schemas, defined as perception of the relationship of body parts to each other and environmental space. Thus, Schwartz and Reilly’s study provided evidence of the mechanisms by which a tool’s characteristics influence the ability to use it in a skilled manner.

Yakimishyn and Magill-Evans (2002) demonstrated how different combinations of task and tool characteristics may interact and have varying effects on pencil grip. They found that the length of the writing implements—but not the diameters—affect grasp patterns. Moreover, in combination, a short writing implement paired with a vertical surface resulted in more mature grip, but no other
combination of conditions had a significant effect on maturity of pencil grip. In addition, orientation of presentation of the writing implement had a significant effect on maturity of grasp. Thus, multiple variables may interact to influence motor skills used with tools.

Consistent with Dynamic Systems Theory, research has shown how aspects of the cognitive system (Connolly & Dalgleish, 1989), the sensory–perceptual system (Schwartz & Reilly, 1981), the motor system (Ratcliffe et al., 2007), and task-related systems (Schwartz & Reilly, 1981; Yakimishyn & Magill-Evans, 2002) can affect tool use both individually and in interaction with each other. These studies have also offered direction for research related to the development of skilled use of other tools, such as scissors. Research examining the effect of task and tool variations on scissor skills could provide guidance for occupational therapy assessment and intervention.

Development of Scissor Skills

Only two studies that investigated the development of scissor grip and cutting motions in children have been published. The first of these was conducted by Karr in 1934. The study participants were typically developing children, ages 2–6 yr, and the study focused on accuracy of cutting, the ability to cut rather than tear with the scissors, speed, hand preferences, and gender differences in cutting skills. General descriptions of scissor grasp and cutting motions were provided, but no analyses of these aspects of the tasks were conducted.

More than 70 yr later, Ratcliffe et al. (2007) conducted a second study of scissor skills. Their study analyzed scissor skills in typical 4- to 6-yr-old South African children. Ratcliffe et al. added to the previous research by using an observation form to gather descriptive data related to cutting skills in addition to gathering accuracy data. Their study revealed that only a small percentage of children used the type of scissor grasp and cutting motions that have traditionally been considered mature (Ratcliffe et al., 2007; Rodger et al., 2003; Schneck & Battaglia, 1992). Ratcliffe et al. concluded that the motor components of cutting skills may not be completely mature by age 6 and recommended that research be conducted to explore cutting skills in 7- and 8-yr-olds. Research investigating scissor grip and cutting motions among adults may also help to clarify acceptable attractor states for scissor grip, the frequency and effectiveness of alternative grips, the influence of task and tool characteristics, and reasonable expectations for children.

To add to the literature related to scissor skills, we addressed the following research questions:

1. What are the characteristics of the grasps and motor patterns typical adults use for cutting?
2. What are the similarities and differences in the motor skills typical adults use with different types of scissors (i.e., circular handles vs. oval handles)?
3. What are the similarities and differences in the motor skills typical adults use when cutting different shapes (i.e., a line, square, circle)?

Method

Participants and Setting

Eighty adults ages 18 yr and older were recruited from among students, faculty, patients, and patients’ family members at the health science center campus of a university in the southern United States. People with disabilities, determined by self-report, were excluded. The study was approved by the University of Tennessee’s institutional review board.

Materials and Procedures

Each participant was tested individually while seated across from the examiner at a standard adult-sized table with an armless chair that allowed the participant’s feet to rest on the floor. A digital video recorder was used to videotape the participant while he or she cut several shapes, first with one type of scissors (oval- or circular-handled) and then with the other type. Efforts were made to exclude faces during videotaping. The videotapes were viewed later for rating purposes.

The shapes were computer generated, and each consisted of lines 1 mm thick. They included a 4.75-in. line, a 3.5-in. square, and a 3.5-in.-diameter circle, based on recommendations by Ratcliffe et al. (2007). The shapes were printed on unlined white office-weight paper approximately 4.25 in. × 5.5 in. in size. The shapes were presented in the same order for each participant and for each pair of scissors, beginning with the line, then the square, and finally the circle.

The two pairs of scissors were both adult sized, with 3-in. blades, and designed for use by either right- or left-handed individuals. One pair had two circular loops, and the other had one circular loop and one oval loop (Figure 1). The scissors were presented by placing them on the table at the participant’s midline, with the handle end closest to the participant. The order of presentation was counterbalanced to control for order effects. Instructions were “Cut this design. Cut right on the line. Stay on the line the best you can.” Each participant completed a total
of six cutting tasks, cutting each set of shapes with each pair of scissors.

Videotapes were rated using a 38-item observation form adapted from Ratcliffe et al. (2007). Gender, age range, preferred hand, and type of scissors presented first were also recorded. Additional observations were noted on the observation form.

Interobserver Agreement

The first 20 videotapes (25% of the sample) were viewed and rated by four of the researchers (Hampton, Hanks, Miller, and Ray) to determine interobserver agreement. The percentage of agreement was 95.76%. Points of disagreement were discussed and clarified before the remaining 60 videotapes were divided equally among the four and scored independently.

Data Analysis

Because of the dichotomous nature of the data, we used nonparametric procedures for the analyses. The $\chi^2$ test of independence was used to determine the presence of order effects (circular handles first vs. oval handles first). Fisher’s exact tests (Daniel, 1990; Siegel & Castellan, 1988) were used when the expected values were <5. McNemar tests (Daniel, 1990; Siegel & Castellan, 1988) were conducted to determine whether any differences in scissors skills were related to the two types of scissors used, and Cochran $Q$ tests (Daniel, 1990; Siegel & Castellan, 1988) were used to determine whether the differences in scissors skills were related to the three shapes cut. Pairwise sign tests were used to follow up significant Cochran $Q$ tests.

Results

Demographics

Participants ranged in age from 22 to 62 yr. More than half of the sample (58.3%) was in the 22–25 age range, and the next largest percentage (8.3%) was in the 26–29 age range. Two other age ranges, 18–21 and 55–58, each composed 6.6% of the sample. The remaining age ranges made up ≤5% of the sample. Of the participants, 33% were male and 67% were female. The overwhelming majority (95%) held the scissors in their right hands, although fewer (90%) reported right-hand dominance.

Order and Shape Effects

The percentages of participants who demonstrated the different motor patterns were identical for many of the 38 items on the observation form, regardless of the type of scissors used first. For those percentages that differed, we detected no statistically significant order effects or Shape $\times$ Order interactions (see Tables 1 and 2). We therefore combined and analyzed all the data to determine whether any differences in motor patterns were based on the type of scissors used or the shapes that were cut.

Grasp of the Scissors

Commonly observed grasps for each type of scissors are shown in Figure 1. All the participants placed their thumbs through the top loop of the scissors, regardless of the type of scissors grasped or the shape being cut, and 95–98.33% of participants placed the loop of the scissors between the distal interphalangeal (DIP) and proximal interphalangeal (PIP) joints of the fingers, with
no statistically significant differences related to the type of scissors used, \( \chi^2 (1, 60) = 0.50, p = .480 \). Statistically significant differences were noted in the percentage of participants who placed different fingers in the bottom loop of the scissors when using the circular versus oval handles (see Table 3). A higher percentage of participants placed their middle \( (\chi^2 [1, 60] = 12.071, p < .001) \), index \( (\chi^2 [1, 60] = 19.048, p < .001) \), ring \( (\chi^2 [1, 60] = 40.024, p < .001) \), and little \( (\chi^2 [1, 60] = 36.026, p < .001) \) fingers through the bottom loop when using the oval-handled scissors than when using the circular-handled scissors.

Stabilization of the scissors also differed according to the type of scissors used. A statistically significant higher percentage of participants placed their index \( (\chi^2 [1, 60] = 20.045, p < .001) \), middle \( (\chi^2 [1, 60] = 12.071, p < .001) \), or index and middle fingers outside the bottom loop and used them to hold the scissors steady when cutting with circular-handled scissors than when cutting with oval-handled scissors. When cutting with circular-handled scissors, significantly more participants also placed their ring \( (\chi^2 [1, 60] = 45.021, p < .001) \), little \( (\chi^2 [1, 60] = 9.091, p < .01) \), or ring and little fingers outside the bottom loop of the scissors (see Table 3).

Of the participants, 70%–78.33% held the scissors parallel to the floor when cutting, and no statistically significant differences were found in the percentage of participants who did so when using the different types of scissors to cut the line \( (\chi^2 [1, 60] = 1.33, p = .248) \), the square \( (\chi^2 [1, 60] = 0.50, p = .480) \), or the circle \( (\chi^2 [1, 60] = 1.33, p = .248) \). Likewise, when using either the circular-handled scissors \( (Q[2] = 4.00, p = .135) \) or the oval-handled scissors \( (Q[2] = 4.67, p = .097) \), we found no statistically significant differences between the percentage of participants who held the scissors parallel to the floor when cutting any of the three different shapes. Percentages of participants who held the scissors parallel to the floor in each condition are reported in Table 3.

### Hand Movements

All the participants demonstrated finger flexion during cutting. Most \( (98.33\%) \) used their radial fingers to mobilize the scissors, while keeping the ulnar fingers flexed and relatively still. No participants demonstrated mass flexion or extension of the fingers or associated reactions during any of the cutting tasks. All participants demonstrated rhythmical, smooth, continuous cutting motions. These patterns were consistent, regardless of the scissors type or the shape being cut.

### Wrist Position and Movement

No statistically significant differences were found in wrist position or movements depending on the type of scissors used, and no frequency differences were statistically significant. Slight wrist extension was observed in 3.33%–6.67%
of participants ($\chi^2[1, 60] = 0.50, p = .480$); wrist flexion was observed in 33.33%–90% of participants ($\chi^2[1, 60] = 3.20, p = .074$); and a neutral wrist position was observed in 71.67%–88.33% of participants ($\chi^2[1, 60] = 0.248, p = 1.33$). Wrist movements were used to make slight adjustments during cutting in 33.33%–96.3% of participants, but again we found no statistically significant differences in percentages related to the different scissor types ($\chi^2[1, 60] = 3.20, p = .074$).

When comparing wrist position and movements used for cutting different shapes, we noted statistically significant differences in three of the four criteria. No statistically significant differences in wrist extension were found with either scissor type ($Q[2] = 2.00, p = .368$), but statistically significant differences were found in the use of wrist flexion, depending on which shape was being cut with either type of scissors. With both circular-handled scissors ($Q[2] = 60.941, p < .001$) and oval-handled scissors ($Q[2] = 54.765, p < .001$), follow-up pairwise sign tests revealed a statistically significant greater percentage of participants demonstrating wrist flexion when cutting both the square and the circle than when cutting the line ($p < .01$). Statistically significant differences were also apparent in the percentage of participants flexing the wrist when using the oval-handled scissors to cut the circle versus the square, with more participants using wrist flexion to cut the circle ($p < .01$). Because of the small sample size, we could not determine whether statistically significant differences existed in the percentage of participants who used neutral wrist positioning when cutting the square versus the circle with either type of scissors, but for both scissor types, a statistically significant larger percentage of participants demonstrated a neutral wrist position when cutting the line than when cutting either the square or the circle ($p < .01$ for both shapes vs. the line with the circular-handled scissors and for the square vs. the line with the oval-handled scissors; $p < .05$ for the circle vs. the line with the oval-handled scissors). Percentages of participants demonstrating neutral wrist positioning for each shape are reported in Table 3.
Statistically significant differences in the percentage of participants using wrist movements to adjust the scissor position when cutting different shapes were noted for both the circular-handled ($Q[2] = 66.50, p < .001$) and the oval-handled ($Q[2] = 59.56, p < .001$) scissors. Pairwise sign tests indicated statistically significant greater percentages of participants who used wrist movement when cutting both the square and the circle than when cutting the line with both types of scissors ($p < .01$). No determination could be made regarding the statistical significance of the difference between percentages of participants using wrist movement when cutting the square versus the circle with circular-handled scissors, but with the oval-handled scissors, a greater percentage of participants used wrist movements for cutting the circle than for cutting the square ($p < .01$). Percentages of participants demonstrating wrist movements when cutting each shape are reported in Table 3.

**Forearm and Elbow Positions**

All of the participants held their forearms in midposition, with their elbows flexed to approximately 90°, regardless of the type of scissors or the shape being cut. None demonstrated pronated or supinated forearms or elbows fixated against their trunks.

**Shoulder Positions and Movement**

Comparing the two scissor types, we found no statistically significant differences in the percentage of participants maintaining the humerus next to the trunk when cutting any of the shapes ($X^2[1, 60] = 1.33, p = .248$). The humerus was next to the trunk for 93.33%–100% of participants, and 33.33%–33.33% of participants used shoulder abduction to mobilize the scissors. We found statistically significant differences in the percentage of participants using circular-handled scissors who held the humerus next to the trunk to cut the shapes ($Q[2] = 6.50, p = .039$), but the small sample size precluded the determination of which shapes accounted for this difference. When participants used oval-handled scissors to cut the different shapes, we found no statistically significant differences in shoulder position ($Q[2] = 2.0, p = 3.68$).

In terms of shoulder movement, we found no statistically significant differences related to scissor type when cutting the line ($X^2[1, 60] = 1.33, p = .248$), the square ($X^2[1, 60] = 0.50, p = .480$), or the circle ($X^2[1, 60] = 0.00, p = 1.00$). However, when using both types of scissors, a statistically significant greater percentage of participants used shoulder abduction to cut both the square and the circle than the line. Small sample size precluded a determination of statistically significant differences between percentages of participants who used shoulder abduction to cut the square versus the circle.

**Assisting Hand**

The position of the assisting hand was consistent across all of the cutting conditions. All participants held the paper with the thumb on top of the paper and fingers flexed underneath it. Forearms were maintained in midposition, with no participants demonstrating pronated or supinated forearms. All participants manipulated the paper for cutting accuracy.

**Discussion**

*Mature Motor Patterns for Cutting*

This study documents the grasps and motor patterns used by a sample of typical adults when cutting different shapes with two different types of scissors. To summarize, most participants held the scissors with the thumb through the top loop and the scissors positioned between the DIP and PIP joints of the fingers. The fingers of the cutting hand were flexed, and movement of the radial fingers was used to open and close the scissors. The ulnar fingers remained flexed and fairly still. The forearm of the cutting hand was maintained in midposition with regard to supination and pronation, and the elbow was flexed at approximately 90°. Scissor grip was constant, and the scissors were held parallel to the floor. Cutting was rhythmic, smooth, and continuous. The adults in the study manipulated the paper for cutting accuracy, holding the paper in the assisting hand, with the thumb on top of the paper and the remaining fingers flexed under the paper. The forearm of the assisting hand was in midposition. These patterns were consistent, regardless of the type of scissors used or the shape being cut.

**Influence of Tool Characteristics**

Despite these consistent patterns, some variations were also observed. The grip and method used to stabilize the scissors varied depending on the type of scissors used. When cutting with circular-handled scissors, the participants tended to place only the middle or only the index finger through the bottom loop. To hold the scissors steady, participants placed their index or middle finger outside the loops, with the ring and little fingers flexed and outside the handles. The most common grip of the circular-handled scissors included placement of the middle finger through the bottom loop of the scissors, with the index finger placed outside the bottom loop and used for...
stabilization. This corresponds to the grip described in the literature as the mature scissors grasp (Ratcliffe et al., 2007; Rodger et al., 2003; Schneck & Battaglia, 1992). By contrast, when the scissors had an oval-shaped lower loop, more of the participants placed the index, middle, ring, or little fingers through the bottom loop of the scissors. The most common grip of the oval-handled scissors consisted of placing the index, middle, and ring fingers through the bottom loop. Thus, when describing the mature scissors grasp, these findings suggest that the type of scissors should be specified. The mature grip for one type of scissors is not necessarily identical to the mature grip for a different type of scissors. These findings are consistent with the dynamic systems view of tool use and similar to Yakimishyn and Magill-Evans (2002) finding that tool and task characteristics may differentially influence the type of grasp used with the tool.

Influence of Task Characteristics on Motor Patterns Used for Cutting

Variations in motor patterns involving the wrist and shoulder were observed, depending on the shape being cut. That is, shoulder abduction was used more often when cutting the more complex shapes—the square and circle—than when cutting the line. Similarly, more wrist flexion and wrist movement were used for cutting complex shapes, especially the circle. When cutting the line, more neutral positioning of the wrist was observed.

Implications for Occupational Therapy Practice

Without empirical data to define mature motor patterns for scissors use, the validity and reliability of assessment of scissors skills is in question. As future research confirms the patterns identified by this study and determines the ages at which they emerge, therapists will be able to more accurately identify strengths and weaknesses in the motor components needed for the development of effective cutting skills. More valid, reliable identification of delays or deficits in scissors skills will, in turn, allow therapists to provide targeted intervention to address specific skills interfering with the ability to cut with scissors.

In summary,

- The most common grasp used by typical adults for circular-handled scissors was thumb through the top loop, middle finger through the bottom loop, index finger outside the bottom loop and used for stabilization, and scissors positioned between the DIP and PIP joints of the fingers.
- The most common grasp used by typical adults for oval-handled scissors was thumb through the top loop; index, middle, and ring fingers through the bottom loop; and scissors positioned between the DIP and PIP joints of the fingers.
- Many of the upper-extremity movements and positions were consistent, regardless of the type of scissors used.
- Participants used more shoulder abduction, wrist flexion, and wrist movement when cutting complex shapes than when cutting a line.
- These findings will assist therapists in recognizing and identifying delays and deficits in cutting skills, in designing therapeutic activities for meeting particular goals, and in developing appropriate task and tool adaptations for meeting the needs of specific people.
Limitations

Although videotaping was advantageous when scoring the items on the observation form, the video recording also had limitations related to it. At times, the viewing angles were less than optimal, and technical difficulties resulted in the loss of some data. Nevertheless, interobserver reliability was high, suggesting that reviewing the videotapes was an acceptable method for collecting the data in this study. Other limitations include the fact that a wide variety of scissors are currently on the market, and this study was limited to two different types. Inclusion of more complex shapes may also have influenced the movement patterns of the typical adults in this study. The small sample size and the fact that most of the participants were in the 22–25-yr age range were additional limitations to the generalizability of these results.

Suggestions for Future Research

Further research is needed, including longitudinal and cross-sectional studies to investigate the development of scissor skills across particular age ranges. Research studies examining changes in scissor skills at 3- or 6-mo intervals, for example, could help clarify small changes in cutting skills that may occur between the 1-yr intervals investigated by Ratcliffe et al. (2007). Studies using other types of scissors with people with disabilities could also assist in determining whether a particular type of scissors might facilitate more mature, effective grip and cutting motions for those with delays or deficits in scissor skills. Future research could also consider variables such as cultural differences and include measurement of cutting accuracy. ▲

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References


