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Date: 27 JAN 2019
The Effect of Twist Direction and Yarn Structure on the Twined Knitting Technique

By Tracey Grzegorczyk

Submitted to Olds College
October 15, 2018
Abstract

Twined knitting, or two-end knitting, is a Scandinavian technique where, as the name implies, two yarn ends are used at the same time. The yarn used for a stitch is alternated back and forth between these two yarn strands, and twisted around each other in a consistent manner as the knitting progresses. Because of this process, the construction of the yarn factors greatly into the end product. References recommend using Z-plied yarn, as the method of throwing and twisting while knitting adds S twist to the yarns. If S-plied yarn is used, more S twist is added, and the yarn becomes both difficult to manage and over-twisted, feeling hard and stiff.

This study compared Z-plied vs. S-plied, 2-ply and 3-ply, and worsted- vs. woollen-spun yarns in both lower- and higher-twist versions of the same construction, to determine the effect on the finished knitted fabric. Miniature mittens were made from the same pattern. The knitting process as well as the features of the finished fabric of the mittens factored into recommendations for desired characteristics of yarns used in twined knitting.

The findings supported the recommendation of a Z-plied yarn, though not all of the Z-plied yarns tested were considered suitable. Some of the yarns did not have enough twist to counteract the introduction of S-twist. The worsted-spun high-twist Z-plied yarns proved most suitable. The study also found that S-plied yarns can be suitable, if they are low twist. As long as the yarn was spun in such a way as to allow for the build-up of S-twist (high-twist Z-plied or low-twist S-plied), the yarn can be suitable for the twined knitting method.
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**Introduction**

Twined knitting, or two-end knitting, is a Scandinavian technique that dates back several centuries. Samples of the technique are linked primarily to areas of Sweden, where it is referred to as *Tvåände stickning*, but also to Denmark and Norway (Dandanell & Danielsson, 1989, p. 9). One sample dates back to at least 1680, when the slag heap under which the item was found was created in Falun, Sweden (Ling, 2004, p 5).

As the name implies, two ends or yarns are used at the same time and twisted around each other in a consistent manner as the knitting progresses. This can be two ends of the same ball of yarn, or one each from two different colors or yarns. Traditionally both strands are held in the right hand, and each strand is wrapped over the other as they alternate being used for stitches (Dandanell & Danielsson, 1989, p. 67). Because of this repetitive motion, the construction of the yarn factors greatly into the end product. References recommend using Z-plied yarn, as the method of throwing and twisting while knitting adds S twist. However, too little Z twist results in much of the ply twist being removed entirely. If S-plied yarn is used, more S twist is added, and the yarn may become both difficult to manage and over-twisted, feeling hard and stiff. Twist is therefore a significant attribute when it comes to making a yarn suitable for its intended purpose (Amos, 2001, p. 105).

The twined knitting technique produces items that are sturdy, not particularly elastic, and insulate well due to the thickness of the fabric (Knitty, 2005). The structure of the yarns used can affect the durability and feel of the finished fabric – insufficient twist can expose individual plies that will wear at a greater rate. Too much twist can result in a rough feeling, and can even cause the fabric to bias. An additional recommendation is to use smooth, worsted-style yarns over woollen, as “a light and lofty woolen yarn in which the fibers are at all angles, is not
suitable. No matter how soft and fine such a yarn feels, it becomes prickly in a large two-end knitted garment” (Ling, 2004, p. 6).

This study looked at multiple attributes of a yarn to determine if there might be a ‘better’ or ‘best’ construction to use in twined knitting:

- S/Z vs. Z/S direction in spinning/plying
- Lower vs. higher twist in the same yarn structure
- 2-ply vs. 3-ply construction
- Worsted vs. woollen spinning technique

Once the yarns were spun, a simple pattern for a miniature mitten was developed and used to create samples.

The expectation is that one or more yarns that are S-spun and Z-plied, with a worsted spinning style, will be evaluated as highly suitable to the twined knitting method. It is also expected that yarns with a higher relative Z twist will be more suitable, else the knitting motion of adding S twist will remove too much of the plying twist for the yarn to remain stable and sturdy.
Materials and Methods

There are a large number of factors that can affect the appropriateness for a particular yarn for an end-use. In this case, because the technique of twined knitting introduces twist into the yarn as it is worked, this study looked at the direction of ply twist (S vs. Z), the amount of twist, and whether the spinning/drafting technique of worsted vs. woollen would affect the performance of the yarn.

Fiber

The fibers used were four different-colored Bond fleeces from the same flock (Joanna Gleason, in Lyons, Colorado, US), primarily for ease of telling samples apart. All had a similar staple length of five (5) inches, and a Bradford count of 56-58s.

- Fleece from ram Serious Black was used for samples #1-4.
- Fleece from ewe Bree was used for samples #5-8.
- Fleece from ewe Sorrel was used for samples #9-12.
- Fleece from ewe Clio was used for samples #13-16.

Bond wool is a very versatile fiber, and is similar to Corriedale. It was developed in Australia in the early 1900s from a cross between Saxon-Peppin Merino ewes and Lincoln rams. This fiber was chosen because it responds well to both worsted and woolen spinning styles. With an average of 22-28 microns, it is not overly coarse nor fine.
All fleeces were scoured as follows: two 5-oz lots of each fleece were put into lingerie bags and soaked in a hot water (140°F/60°C) wash using Unicorn Power Scour for 20 minutes, followed by another hot water wash of the same duration, then two plain hot water rinse soaks of 15 minutes each. The bags were removed from the last rinse and allowed to drain. The clean fleece was then spread onto mesh racks and allowed to dry completely over several days.

Once dry, the fiber was drum-carded on an electric Patrick Green carder, and then dizzed off to roving. All spun samples started with this same preparation for consistency, and allowed for spinning both worsted and woollen from this preparation (Ross, 1983, p. 40).
**Spinning**

Spinning was done on a number of different wheels, based on the style required for the sample. Higher-twist yarns were spun on an Ashford Elizabeth 30” Production wheel. Lower-twist yarns were spun on either a double-treadle Lendrum upright, or a Carson Cooper Sabrina upright.

For the woollen-spun yarns, the long-draw technique was used with the drum-carded roving. For the worsted-spun yarns, the short forward draw method was used with the drum-carded roving.

**Knitting**

The following pattern was developed by the author using the twined knitting technique for the sample mittens.

The twined knitting technique involves using two strands, either from the same center-pull ball (as in this case) or from two separate balls of yarn. Stitches from each strand alternate and wrap around each other on the back, or wrong, side. The yarns are traditionally both carried in the right hand, and are always wrapped in the same direction around each other as they are alternately used from stitch to stitch.

A false-ribbing is achieved by the “deep knit” stitch: after a knit stitch is done, the strand used for that stitch is moved to the front of the work and the next knit stitch is worked with the other strand (Brown-Reinsel, Lesson 3, 14:35). The forward strand is then moved to the back and twisted around the other strand before it is used to make the next stitch. When a regular and deep knit stitch alternate, it creates a type of faux-ribbing.

Part of the twined-knitting process allows for either the item or ball of yarn to dangle at regular intervals, allowing built-up twist to reduce. Traditionally a half-hitch was made around the yarn ball to secure the ends while it dangled and spun. This is preferred when making a large
garment such as a sweater. With smaller items, or items using two different yarns at one time, it may be easier to allow the item to dangle and untwist.

**Mitten Pattern**

Numbers are for lower-twist yarns (higher-twist yarns).

1. Cast on 32 (42) stitches using the long-tail cast-on method on to 4 mm (3 mm) needles.

2. Using twined knitting method, knit 1 (1) round.

3. Knit 6 (8) rounds of deep-knit (faux ribbing): *k1, dk1* to end

4. Set up thumb: m1, k1, m1; place marker and knit to end.

5. Increase for thumb: Knit two rounds; on third round, m1, knit to marker, m1; slip marker and knit to end. Complete 5 (6) sets of these three rounds.

6. Place first 13 (15) stitches on waste yarn and remove marker. Join yarn, cast on 1 (1) stitch, and continue knitting in the round for 12 (12) rounds.

7. Create top: *k1, ssk, then k10 (15), k2tog, k1*. Place marker and repeat **.

8. Continue: *k1, ssk, knit to 3 st before marker, k2tog, k1* repeat ** to end.

9. Continue this round until less than 10 st remain. Cut yarn with 12" tail. Using darning needle, thread both strands through remaining stitches and pull tight to close. Secure on inside and weave in ends.

10. Thumb: put remaining 13 (15) st on needles.

11. Pick up one st at start, and knit 6 (8) rounds.

12. Next round: SSK around, leaving 7 (8) stitches.

13. Cut yarn with 8" tail. Using darning needle, thread both strands through remaining stitches and pull tight to close. Secure on inside and weave in ends.

14. Use yarn tails to close up hole between mitten and thumb, and weave in ends.

15. Weave In ends at cuff.
Results

A total of 16 yarns were spun per the following list:

<table>
<thead>
<tr>
<th>Yarn Sample</th>
<th>Description</th>
<th>Spin Style</th>
<th>Singles</th>
<th>Plyes</th>
<th>TPI</th>
<th>Suitability</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Worsted-spun, 2-ply, Z/S, lower twist</td>
<td>Worsted</td>
<td>Z</td>
<td>S</td>
<td>3.5</td>
<td>Low, not durable</td>
</tr>
<tr>
<td>2</td>
<td>Worsted-spun, 2-ply, Z/S, higher twist</td>
<td>Worsted</td>
<td>Z</td>
<td>S</td>
<td>7</td>
<td>Low, odd texture</td>
</tr>
<tr>
<td>3</td>
<td>Worsted-spun, 2-ply, S/Z, lower twist</td>
<td>Worsted</td>
<td>S</td>
<td>Z</td>
<td>3.5</td>
<td>Not suitable</td>
</tr>
<tr>
<td>4</td>
<td>Worsted-spun, 2-ply, S/Z, higher twist</td>
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<td>S</td>
<td>Z</td>
<td>7</td>
<td>Suitable</td>
</tr>
<tr>
<td>5</td>
<td>Worsted-spun, 3-ply, Z/S, lower twist</td>
<td>Worsted</td>
<td>Z</td>
<td>S</td>
<td>2.3</td>
<td>Suitable</td>
</tr>
<tr>
<td>6</td>
<td>Worsted-spun, 3-ply, Z/S, higher twist</td>
<td>Worsted</td>
<td>Z</td>
<td>S</td>
<td>5</td>
<td>Low, odd texture</td>
</tr>
<tr>
<td>7</td>
<td>Worsted-spun, 3-ply, S/Z, lower twist</td>
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<td>S</td>
<td>Z</td>
<td>2.7</td>
<td>Not suitable</td>
</tr>
<tr>
<td>8</td>
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<td>S</td>
<td>Z</td>
<td>6</td>
<td>Suitable</td>
</tr>
<tr>
<td>9</td>
<td>Woollen-spun, 2-ply, Z/S, lower twist</td>
<td>Woollen</td>
<td>Z</td>
<td>S</td>
<td>3</td>
<td>Low, not durable</td>
</tr>
<tr>
<td>10</td>
<td>Woollen-spun, 2-ply, Z/S, higher twist</td>
<td>Woollen</td>
<td>Z</td>
<td>S</td>
<td>6</td>
<td>Low, odd texture</td>
</tr>
<tr>
<td>11</td>
<td>Woollen-spun, 2-ply, S/Z, lower twist</td>
<td>Woollen</td>
<td>S</td>
<td>Z</td>
<td>3.5</td>
<td>Not suitable</td>
</tr>
<tr>
<td>12</td>
<td>Woollen-spun, 2-ply, S/Z, higher twist</td>
<td>Woollen</td>
<td>S</td>
<td>Z</td>
<td>4.5</td>
<td>Not suitable</td>
</tr>
<tr>
<td>13</td>
<td>Woollen-spun, 3-ply, Z/S, lower twist</td>
<td>Woollen</td>
<td>Z</td>
<td>S</td>
<td>3</td>
<td>Suitable</td>
</tr>
<tr>
<td>14</td>
<td>Woollen-spun, 3-ply, Z/S, higher twist</td>
<td>Woollen</td>
<td>Z</td>
<td>S</td>
<td>5</td>
<td>Low, odd texture</td>
</tr>
<tr>
<td>15</td>
<td>Woollen-spun, 3-ply, S/Z, lower twist</td>
<td>Woollen</td>
<td>S</td>
<td>Z</td>
<td>3</td>
<td>Not suitable</td>
</tr>
<tr>
<td>16</td>
<td>Woollen-spun, 3-ply, S/Z, higher twist</td>
<td>Woollen</td>
<td>S</td>
<td>Z</td>
<td>5</td>
<td>Not suitable</td>
</tr>
</tbody>
</table>

Figure 5: List of yarns used

The study was designed so that pairs of yarns were done in a lower- and higher-twist version, so that they could be compared to one another as well as to other yarns of differing ply number or singles/ply twist direction. In the case of the worsted-spun yarns, the high twist yarns were roughly double the TPI of the low twist yarns. However, with the woollen-spun yarns, attempting to get twice the TPI between low- and high-twist versions either resulted in a yarn that was too low-twist and was unstable, or a yarn that had too much twist to actually use a woollen drafting method. In these yarns the TPI was more similar.

Each yarn was used to knit a small sample mitten using the twined knitting technique. All eight lower-twist yarn mittens were knit with the same stitch count and needle size. All eight higher-twist yarn mittens were knit with the same stitch count and needle size. All followed the same pattern developed specifically for this project, as described in the Materials and Methods section.
**Yarn 1:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Spinning style</td>
<td>Worsted</td>
</tr>
<tr>
<td>Number of plies</td>
<td>2</td>
</tr>
<tr>
<td>Singles direction</td>
<td>Z</td>
</tr>
<tr>
<td>Ply direction</td>
<td>S</td>
</tr>
<tr>
<td>Twist</td>
<td>Low</td>
</tr>
</tbody>
</table>

**Evaluation:**

With a low twist 2-ply Z-S yarn, each round resulted in additional twist being added to each yarn strand, causing them to progressively narrow toward the end of each round. Because the yarn was relatively low twist to begin with, the effect was not overly pronounced, but it did cause the stitches at the end of each round to be narrower and denser. Allowing the work to dangle and untwist at the end of each hand round (or three rounds on the thumb) ‘reset’ the strands. Compared to the high-twist Z-S 2-ply yarn (sample #2), the overall effect was a much softer fabric. It does not display the durability characteristic of twined-knitted items.

**Conclusion:** Low suitability; a soft and lofty fabric, but low durability.

![Image of Yarn 1 in use](image.png)

*Figure 6: Yarn 1 in use*
Yarn 2:

Spinning style: Worsted
Number of plies: 2
Singles direction: Z
Ply direction: S
Twist: High

Evaluation:

With a high twist 2-ply Z-S yarn, each round also resulted in additional twist to each strand of yarn. Because the yarn was already more compact in nature due to higher twist and a worsted-style spinning method, the effect was not as pronounced from beginning to end of the round as in the low-twist yarn. Allowing the work to dangle and untwist at the end of each hand round (or three rounds on the thumb) ‘reset’ the strands. Overall, the resulting fabric was even, but the stitches became highly defined – with S-slanted ridges across the width of the fabric. This was a very unusual and unexpected effect in the knitted fabric, and was a characteristic seen in all four of the high-twist Z-S yarns (samples #2, #6, #10 and #14).

Conclusion: Low suitability; this may be acceptable if the unusual texture is desired.
Yarn 3:

<table>
<thead>
<tr>
<th>Spinning style:</th>
<th>Worsted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of plies:</td>
<td>2</td>
</tr>
<tr>
<td>Singles direction:</td>
<td>S</td>
</tr>
<tr>
<td>Ply direction:</td>
<td>Z</td>
</tr>
<tr>
<td>Twist:</td>
<td>Low</td>
</tr>
</tbody>
</table>

**Evaluation:**

With a low twist 2-ply S-Z yarn, each round saw ply twist removed from each strand and pronounced separation of the plies. As Figure 4 below shows, by the end of the round the plies were almost acting as separate singles yarns. Allowing the work to dangle and untwist at the end of each hand round (or three rounds on the thumb) allowed the two yarn strands to separate, but did not fully restore the ply twist to each strand. Without the ply twist, the individual plies in each stitch would be less protected from abrasion, causing faster wear to the mitten. The resulting fabric was texturally similar to the sample using its opposite construction (Yarn #1), but the lack of ply twist in the individual strands would make it more likely to wear faster.

**Conclusion:** Not suitable.

**Figure 9: Yarn 3 with plies separating**

**Figure 10: Yarn 3 in use**
Yarn 4:

<table>
<thead>
<tr>
<th>Spinning style:</th>
<th>Worsted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of plies:</td>
<td>2</td>
</tr>
<tr>
<td>Singles direction:</td>
<td>S</td>
</tr>
<tr>
<td>Ply direction:</td>
<td>Z</td>
</tr>
<tr>
<td>Twist:</td>
<td>High</td>
</tr>
</tbody>
</table>

**Evaluation:**

With a high twist 2-ply S-Z yarn, each round saw ply twist removed as with the low-twist yarn, but at a slower rate. There was not an appreciable difference between the yarn strands at the beginning and end of each round, allowing for more consistent stitches. More ply twist remained in each strand, so that the work did not suffer from exposed single ply strands to the extent that the mitten from Yarn #3 displayed. The fabric also did not display the unusual horizontal stitch definition as did the sample from the opposite yarn construction (Yarn #2).

**Conclusion:** Suitable.

![Image](image_url)
Yarn 5:

<table>
<thead>
<tr>
<th>Spinning style:</th>
<th>Worsted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of plies:</td>
<td>3</td>
</tr>
<tr>
<td>Singles direction:</td>
<td>Z</td>
</tr>
<tr>
<td>Ply direction:</td>
<td>S</td>
</tr>
<tr>
<td>Twist:</td>
<td>Low</td>
</tr>
</tbody>
</table>

**Evaluation:**

Similar to the low twist 2-ply Z-S yarn in sample #1, each round did result in adding additional twist to each yarn strand and causing them to progressively narrow toward the end of each round. The additional ply did exacerbate the effect to the point that the strands were twisted into a much narrower diameter by the end of a round, as shown in Figure 7. Allowing the work to dangle and untwist at the end of each hand round (or three rounds on the thumb) 'reset' the strands of yarn. This was not an overly negative effect with the small number of stitches per round, but on a large garment it would not be desirable. The resulting fabric is dense, fairly even, insulating and durable.

**Conclusion:** Suitable – with the caveat that this is true for smaller items.

![Figure 12: Twist build-up in yarn 5](image1.png)  ![Figure 13: Yarn 5 in use](image2.png)
Yarn 6:

<table>
<thead>
<tr>
<th>Spinning style:</th>
<th>Worsted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of plies:</td>
<td>3</td>
</tr>
<tr>
<td>Singles direction:</td>
<td>Z</td>
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<tr>
<td>Ply direction:</td>
<td>S</td>
</tr>
<tr>
<td>Twist:</td>
<td>High</td>
</tr>
</tbody>
</table>

**Evaluation:**

Similar to the high twist 2-ply Z-S yarn, each round also resulted in additional twist to each strand. Because the yarn was already more compact in nature due to higher twist and a worsted spinning method, the effect was not as pronounced from beginning to end of the round as in the low-twist yarn. Overall it created a stiffer fabric due to twist being added to an already high-twist yarn. This sample also displayed the exaggerated fabric texture similar to sample #2. Allowing the work to dangle and untwist at the end of each hand round (or three rounds on the thumb) ‘reset’ the strands. Overall, there were consistent yet dense stitches.

**Conclusion:** Low suitability; this may be acceptable if the unusual texture is desired.

![Figure 14: Yarn 6 in use](image1)

![Figure 15: Yarn 6 in use](image2)


Yarn 7:

<table>
<thead>
<tr>
<th>Spinning style:</th>
<th>Worsted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of plies:</td>
<td>3</td>
</tr>
<tr>
<td>Singles direction:</td>
<td>S</td>
</tr>
<tr>
<td>Ply direction:</td>
<td>Z</td>
</tr>
<tr>
<td>Twist:</td>
<td>Low</td>
</tr>
</tbody>
</table>

Evaluation:

As with the low twist 2-ply S-Z yarn (Yarn #3), each round saw ply twist removed and pronounced separation of the plies. As Figure 11 below shows, by the end of the round the plies were almost acting as separate singles yarns. The individual plies are apparent in the fabric. Allowing the work to dangle and untwist at the end of each hand round (or three rounds on the thumb) allowed the two yarn strands to separate, but did not fully restore the ply twist to each strand. Without the ply twist, the individual plies in each stitch would be less protected from abrasion, causing faster wear to the mitten as with Yarn #3.

Conclusion: Not suitable.

Figure 16: Yarn 7 showing separation of plies

Figure 17: Yarn 7 in use
Yarn 8:

<table>
<thead>
<tr>
<th>Spinning style:</th>
<th>Worsted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of plies:</td>
<td>3</td>
</tr>
<tr>
<td>Singles direction:</td>
<td>S</td>
</tr>
<tr>
<td>Ply direction:</td>
<td>Z</td>
</tr>
<tr>
<td>Twist:</td>
<td>High</td>
</tr>
</tbody>
</table>

**Evaluation:**

With a high twist 3-ply S-Z yarn, each round saw ply twist removed as with the low-twist yarn, but at a slower rate. There was not an appreciable difference between the yarn strands at the beginning and end of each round, allowing for more consistent stitches. More ply twist remained in each strand, so that the fabric does not suffer from exposed single ply strands to the extent that the mitten from yarn sample #7 displayed.

**Conclusion:** Suitable.

*Figure 18: Yarn 8 in use*
Yarn 9:

<table>
<thead>
<tr>
<th>Spinning style:</th>
<th>Woollen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of plies:</td>
<td>Z</td>
</tr>
<tr>
<td>Singles direction:</td>
<td>Z</td>
</tr>
<tr>
<td>Ply direction:</td>
<td>S</td>
</tr>
<tr>
<td>Twist:</td>
<td>Low</td>
</tr>
</tbody>
</table>

**Evaluation:**

As with the worsted-spun low twist 2-ply Z-S yarn, each round did result in additional twist to each yarn strand and causing them to progressively narrow toward the end of each round. Because the yarn was relatively low twist, the effect was not overly pronounced, but it did cause the stitches at the end of each round to be narrower and denser. Allowing the work to dangle and untwist at the end of each hand round (or three rounds on the thumb) ‘reset’ the strands. As with the worsted-spun version of this yarn, the fabric is soft and lofty, but may not wear as well as a high-twist yarn.

Conclusion: Low suitability; a soft and lofty fabric, but low durability.

![Figure 19: Yarn 9 in use](image)
Yarn 10:

<table>
<thead>
<tr>
<th>Spinning style:</th>
<th>Woollen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of plies:</td>
<td>2</td>
</tr>
<tr>
<td>Singles direction:</td>
<td>Z</td>
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<tr>
<td>Ply direction:</td>
<td>S</td>
</tr>
<tr>
<td>Twist:</td>
<td>High</td>
</tr>
</tbody>
</table>

Evaluation:

With a high twist 2-ply Z-S yarn, each round also resulted in additional twist to each strand. Unlike the worsted-spun 2-ply Z-S yarn (Yarn #2), there was a more pronounced narrowing of the strands with the woollen-spun yarns toward the end of each round. This also negated the airy nature of woollen-spun yarns. This fabric also displayed the pronounced horizontal pattern similar to Yarns #2 and #6. Allowing the work to dangle and untwist at the end of each hand round (or three rounds on the thumb) 'reset' the strands.

Conclusion: Low suitability; this may be acceptable if the unusual texture is desired.

![Image of Yarn 10 in use](image1.png)  
*Figure 20: Yarn 10 in use*  

![Image of Yarn 10 in use](image2.png)  
*Figure 21: Yarn 10 in use*
Yarn 11:

<table>
<thead>
<tr>
<th>Spinning style:</th>
<th>Woollen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of plies:</td>
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</tr>
<tr>
<td>Singles direction:</td>
<td>S</td>
</tr>
<tr>
<td>Ply direction:</td>
<td>Z</td>
</tr>
<tr>
<td>Twist:</td>
<td>Low</td>
</tr>
</tbody>
</table>

Evaluation:

With a low twist 2-ply S-Z yarn, each round saw ply twist removed and pronounced separation of the plies. As figure 17 below shows, by the end of the round the plies were almost acting as separate singles yarns. Allowing the work to dangle and untwist at the end of each hand round (or three rounds on the thumb) allowed the two yarn strands to separate, but did not fully restore the ply twist to each strand. Without the ply twist, the individual plies in each stitch would be less protected from abrasion, causing faster wear to the mitten – especially with woollen-spun yarn. The individual plies are readily apparent in the stitches of the fabric.

Conclusion: Not suitable.

Figure 22: Yarn 11 showing separation of plies  
Figure 23: Yarn 11 in use
Yarn 12:

Spinning style: Woollen
Number of plies: 2
Singles direction: S
Ply direction: Z
Twist: High

Evaluation:

With a high twist 2-ply S-Z yarn, each round saw ply twist removed as with the low-twist yarn. This occurred at a slower rate than with the low-twist yarn sample #11, but with the woollen-spun nature of the yarn, loss of ply twist compromises the strength of the yarn. As seen in the stitches on the needle in Figure 19, and in the fabric of the finished sample, the individual strands are clearly visible in each stitch.

Conclusion: Not suitable.

Figure 24: Yarn 12 showing separation of plies
Yarn 13:

<table>
<thead>
<tr>
<th>Spinning style:</th>
<th>Woollen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of plies:</td>
<td>3</td>
</tr>
<tr>
<td>Singles direction:</td>
<td>Z</td>
</tr>
<tr>
<td>Ply direction:</td>
<td>S</td>
</tr>
<tr>
<td>Twist:</td>
<td>Low</td>
</tr>
</tbody>
</table>

**Evaluation:**

Similar to the low twist 2-ply Z-S yarn (#9), each round did result in adding additional twist to each strand and causing them to progressively narrow toward the end of each round. The additional ply did exacerbate the effect to the point that the strands were twisted into a much narrower diameter by the end of a round, as shown in Figure 20. Allowing the work to dangle and untwist at the end of each hand round (or three rounds on the thumb) ‘reset’ the strands of yarn. The additional twist did not fully negate the woollen nature of the yarn, in that the finished fabric has a nice feel, and is dense without being stiff.

**Conclusion:** Suitable.
Yarn 14:

Spinning style: Woollen
Number of plies: 3
Singles direction: Z
Ply direction: S
Twist: High

Evaluation:

Similar to the high twist 2-ply Z-S yarn, each round also resulted in additional twist to each strand. Despite the woollen nature of the yarn, with the higher ply twist, the effect was not as pronounced from beginning to end of the round as in the low-twist yarn. Overall, however, it created a stiffer fabric due to twist being added to an already high-twist yarn. This fabric displays the same pronounced pearl-like bump in each stitch, as did Yarns #2, #6 and #10. Allowing the work to dangle and untwist at the end of each hand round (or three rounds on the thumb) 'reset' the strands.

Conclusion: Low suitability; this may be acceptable if the unusual texture is desired.

Figure 27: Yarn 14 showing texture  
Figure 28: Yarn 14 in use
Yarn 15:

Spinning style: Woollen
Number of plies: 3
Singles direction: S
Ply direction: Z
Twist: Low

Evaluation:

As with the low twist 2-ply S-Z yarns, each round saw ply twist removed and pronounced separation of the plies. As Figure 24 below shows, by the end of the round the plies were almost acting as separate singles yarns. Figure 25 shows the stitches on the needle, with each of the three plies clearly defined. Allowing the work to dangle and untwist at the end of each hand round (or three rounds on the thumb) allowed the two yarn strands to separate, but did not fully restore the ply twist to each strand. Without the ply twist, the individual plies in each stitch would be less protected from abrasion, causing faster wear to the mitten as with yarn samples #11 and #12. The individual plies are apparent in the stitches of the fabric.

Conclusion: Not suitable.
Yarn 16:

Spinning style: Woollen

Number of plies: 3

Singles direction: S

Ply direction: Z

Twist: High

Evaluation:

With a high twist 3-ply S-Z yarn, there was not an appreciable difference between the yarn strands at the beginning and end of each round, allowing for more consistent stitches. More ply twist remained in each strand, so that the fabric does not suffer from exposed single ply strands to the extent that the mitten from Yarn #15 displayed, but the individual plies are still evident in the stitches as seen in Figure 26. This results in less durability in the fabric and faster wear to the garment.

Conclusion: Not suitable.

Figure 31: Yarn 16 showing separation of plies
Conclusion

There were a total of four yarns that seemed suitable for the twined knitting technique. Two were anticipated (being the recommended S-spun, Z-plied construction), but the other two were a bit of a surprise.

Most of the yarns and finished samples were able to be grouped by certain characteristics and have similar final evaluations. The final recommendation for which yarn structures work well includes several options for the spinner.

Z-S High Twist Yarns

The four mittens made from the Z-S high twist yarns (samples #2, #6, #10 and #14) all exhibited the same enhanced texture characteristic unusual to normal knitted fabric. With the twined knitting technique introducing additional twist into a higher-twist yarn, each row had exaggerated bumps, almost like a compressed string of pearls. While this would make a very durable fabric, the texture may not be acceptable in some uses.

Z-S 2-ply Low Twist Yarns

The two mittens made from Yarns #1 and #9 were both soft and lofty, despite the twined knitting technique adding more S twist. Because these yarns were initially low twist, and due to the low number of stitches per round on the mittens, the additional twist was not enough to negate the softness. These samples are acceptable though they might not be as durable as some of the other samples.

Woollen-spun S-Z Yarns

The four S-Z woolen-spun yarns (#11, #12, #15 and #16) all suffered from excessive loss of twist during the twined knitting process. With these yarns, introducing S twist from knitting into the Z-plied yarns had the effect of removing almost all of the ply twist. As a result, the individual plies are evident in many of the stitches. Without the ply twist, this is similar to holding singles
yarns together while knitting, and there is no ply twist to protect the individual plies. This results in a more fragile fabric that is prone to pilling and wear, and possibly severed plies leading to holes.

**Worsted-spun Low-Twist S-Z Yarns**

Similar to the four S-Z woollen yarns mentioned above, these two mittens (Yarns #3 and #7) suffered from the same loss of ply twist during knitting and the resulting fabric, with the individual plies evident in the stitches, will not be durable in the long run.

The above twelve samples were all judged to be less than satisfactory or not suitable for use for twined knitting. This leaves four yarns and their samples to be evaluated and recommended for use with the twined knitting technique.

**Yarn #4: Worsted-spun, 2-ply, S-Z, high-twist**

The twined knitting technique caused the Z-ply twist to be removed, but due to the higher amount of initial twist compared to other low-twist yarns, not enough was removed during each knitted round to significantly impact the fabric and stitches. The caveat to this is that it proved to be acceptable in a project where the rounds are relatively short. In a larger project, the spinner would need to evaluate the amount of ply twist against a larger stitch count, and either compensate with more ply twist, or stop more often to let the yarns untwist and reset before continuing. Overall, this proved to be an acceptable yarn for twined knitting.

**Yarn #5: Worsted-spun, 3-ply, Z-S, low-twist**

Although more S twist was added during the knitting process, the initial low twist content of the yarn meant that by the end of a round of knitting, there was not an excessive amount of ply twist in the yarn or stitches. The resulting fabric is sturdy but not stiff. The construction of this yarn is counter to the recommended S-spun/Z-plied, but the low initial twist content allowed for
the buildup of additional S twist without it becoming a detriment to the fabric. This also is an acceptable yarn.

Yarn #8: Worsted-spun, 3-ply, S-Z, high-twist

There was an expectation at the beginning of this project that this yarn construction would work well with the twined knitting technique, and this held true. As with Yarn #4, the 2-ply version of this yarn, the 3-ply yarn also worked well. The instruction of S twist to the higher-twist Z-plied yarn resulted in loss of twist over the knitted round, but the yarn was still structurally sound with sufficient twist to make an acceptable knitted fabric.

Yarn #13: Woollen-spun, 3-ply, Z-S, low-twist

This is the woollen-spun counterpart to Yarn #5, also a 3-ply Z-S low-twist yarn. Similar to Yarn #5, more S twist was added while knitting a round of the twined technique, but it was not so much that the fabric was overly stiff. While unexpected, this yarn construction also was acceptable for twined knitting.

In conclusion, the initial expectation was that the four S-spun/Z-plied higher-twist yarns (Yarns #4, #8, #12 and #16) would perform the best in the knitted samples. Samples #4 and #8, both spun worsted style, were found to perform well with the twined knitting technique. However, the woollen spinning technique used for Yarns #12 and #16 does not lend itself to high-twist yarns. Even a relatively high-twist woollen-spun Z-plied yarn does not have enough twist to counteract the introduction of S twist while knitting with the twined technique. Attempting to get a higher twist-per-inch count out of a woollen-spun yarn would negate the woollen properties of the yarn, as well as make the drafting difficult and tedious with the rapid rate of twist entering into the fiber supply.
What was unexpected was the suitability of the two 3-ply Z-S low-twist yarns (samples #5 and #13). While more S twist was added, it was not enough in the shorter round of a mitten project to cause the fabric to be unacceptable. The 2-ply equivalent yarns, samples #1 and #9, did not have enough twist added to make a durable fabric, though the resulting sample mittens were soft and lofty. They would be comfortable but not wear as well as the 3-ply yarn mittens.

The results for this study are by no means an exhaustive look at all possible factors that would affect the suitability of a yarn for the twined knitting technique. Additional lines of inquiry might look at other fiber preparations from which to spin, or different sheep breeds with finer or coarser fleece. Fiber blends (using silk, camelid, or synthetic fibers) might also affect suitability. Cotton and linen have also been used in twined knitting (Dandanell & Danielsson, 1989, p. 56). Knitting flat may require different yarn properties than those which are suitable for twined knitting in the round. Additionally, non-traditional yarn structures such as those used to create cabled yarns might prove interesting when used for twined knitting.
Bibliography


Appendix

The following pages contain the samples for the sixteen yarns used in this study. The mitten that was knitted from each yarn, using the twined knitting technique, is also included.
Yarn Sample 1 – 100% Bond
Singles Z, Plied S, 2 plies, Worsted style
TPI: 3.5, WPI 9, Angle 60°
5.3 gm / 10 yds  Count: 2/3s

Yarn Sample 2 – 100% Bond
Singles Z, Plied S, 2 plies, Worsted style
TPI: 7, WPI 15, Angle 55°
3.5 gm / 10 yds  Count: 2/4.5s
Yarn Sample 3 – 100% Bond
Singles S, Plied Z, 2 plies, Worsted style
TPI: 3.5, WPI 9, Angle 50°
5.6 gm / 10 yds Count: 2/2.9s

Yarn Sample 4 – 100% Bond
Singles S, Plied Z, 2 plies, Worsted style
TPI: 7, WPI 18, Angle 55°
3.5 gm / 10 yds Count: 2/4.5s
Yarn Sample 5 – 100% Bond
Singles Z, Plied S, 3 plies, Worsted style
TPI: 2.3, WPI 7, Angle 55°
10.6 gm / 10 yds  Count: 3/2.3s

Yarn Sample 6 – 100% Bond
Singles Z, Plied S, 3 plies, Worsted style
TPI: 5, WPI 13, Angle 50°
6.1 gm / 10 yds  Count: 3/3.9s
Yarn Sample 7 – 100% Bond
Singles S, Plied Z, 3 plies, Worsted style
TPI: 2.7, WPI 7, Angle 55°
11 gm / 10 yds  Count: 3/2.2s

Yarn Sample 8 – 100% Bond
Singles S, Plied Z, 3 plies, Worsted style
TPI: 6, WPI 14, Angle 45°
5.1 gm / 10 yds  Count: 3/4.9s
Yarn Sample 9 – 100% Bond
Singles Z, Plied S, 2 plies, Woollen style
TPI: 3, WPI 10, Angle 45°
4.9 gm / 10 yds  Count: 2/6s

Yarn Sample 10 – 100% Bond
Singles Z, Plied S, 2 plies, Woollen style
TPI: 6, WPI 15, Angle 40°
4.9 gm / 10 yds  Count: 2/6s
Yarn Sample 11 – 100% Bond
Singles S, Plied Z, 2 plies, Woollen style
TPI: 3.5, WPI 12, Angle 45°
4.1 gm / 10 yds  Count: 2/7.3s

Yarn Sample 12 – 100% Bond
Singles S, Plied Z, 2 plies, Woollen style
TPI: 4.5, WPI 15, Angle 50°
3.4 gm / 10 yds  Count: 2/8.8s
Yarn Sample 13 – 100% Bond
Singles Z, Plied S, 3 plies, Woollen style
TPI: 3, WPI 9, Angle 45°
8.7 gm / 10 yds  Count: 3/5s

Yarn Sample 14 – 100% Bond
Singles Z, Plied S, 3 plies, Woollen style
TPI: 5, WPI 14, Angle 50°
7.1 gm / 10 yds  Count: 3/6.4s
Yarn Sample 15 – 100% Bond
Singles S, Plied Z, 3 plies, Woollen style
TPI: 3, WPI 9, Angle 45°
7.6 gm / 10 yds  Count: 3/5.9s

Yarn Sample 16 – 100% Bond
Singles S, Plied Z, 3 plies, Woollen style
TPI: 5, WPI 13, Angle 55°
7.2 gm / 10 yds  Count: 3/6.4s