

# Neurotechnology+0005

Neurotechnology

*Slap Fingerprint Segmentation Evaluation III*

*Last Updated: 10 March 2021*

## Contents

|          |  |           |
|----------|--|-----------|
| <b>1</b> | <b>Participation Information</b>                           | <b>2</b>  |
| 1.1      | Names and Dates . . . . .                                  | 2         |
| 1.2      | Libraries . . . . .  | 2         |
| <b>2</b> | <b>Tenprint Cards (“TwoInch” Data)</b>                     | <b>3</b>  |
| 2.1      | Segmentation Timing . . . . .                              | 3         |
| 2.2      | Segmentation Centers and Dimensions . . . . .              | 4         |
| 2.3      | Detailed Segmentation Statistics . . . . .                 | 10        |
| 2.4      | Handling Troublesome Images . . . . .                      | 13        |
| 2.5      | Determining Orientation . . . . .                          | 15        |
| <b>A</b> | <b>Tenprint Cards (“TwoInch” Data)</b>                     | <b>16</b> |
| A.1      | Bootstrap Confidence for Segmentation Statistics . . . . . | 16        |
| A.2      | Jaccard Index . . . . .                                    | 19        |

# 1 Participation Information

## 1.1 Names and Dates

- **Organization Name:** Neurotechnology
- **SlapSeg III Identifier:** Neurotechnology+0005
- **Provided Marketing Name:** “MegaMatcher”
- **Application Date:** 09 March 2021
- **First Submission Date:** 09 March 2021 (as version 0005)
- **Validation Date:** 10 March 2021
- **Completion Date:** 10 March 2021

## 1.2 Libraries

| Filename                              | MD5 Checksum                     | Size     |
|---------------------------------------|----------------------------------|----------|
| libMKLDNNPlugin.so                    | 7f5b4e65ef68fa9c324b7c4ce9f78f4f | 13.5 Mb  |
| Fingers2.ndf                          | 3d215c04477becc48a3ec4aed6f14704 | 142.9 Kb |
| libslapsegiii_Neurotechnology_0005.so | 8729b1c9871369393f71e8d6c4aa0eee | 10.1 Mb  |
| libmkl_tiny.so                        | 78499860662633254ebdff4168be8b60 | 24 Mb    |
| Fingers.ndf                           | 26db0c16dee91a37c54432e111803e0c | 3.2 Mb   |
| libinference_engine.so                | 5a8868c1006db49a93af7e2c21aa62b4 | 2.3 Mb   |
| libiomp5.so                           | 2de0b9ab4a5b58d0174de20891b78775 | 2 Mb     |
| libcpu_extension.so                   | c9b8d94bfb3cab0a078af19cc966959d | 147.1 Kb |

## 2 Tenprint Cards (“TwoInch” Data)

### 2.1 Segmentation Timing

All algorithms are run over a small fixed corpus of TwoInch images to estimate the total runtime of the evaluation. To be evaluated under SlapSeg III, algorithms **must** segment the timing corpus, on average, in under 1 500 milliseconds. This maximum reference time is documented in the SlapSeg III test plan, and is subject to change.

Box plots of segmentation times are separated by slap orientation and capture technology in Figure 1. Tabular representations are enumerated in Table 1. Results are reported in milliseconds.

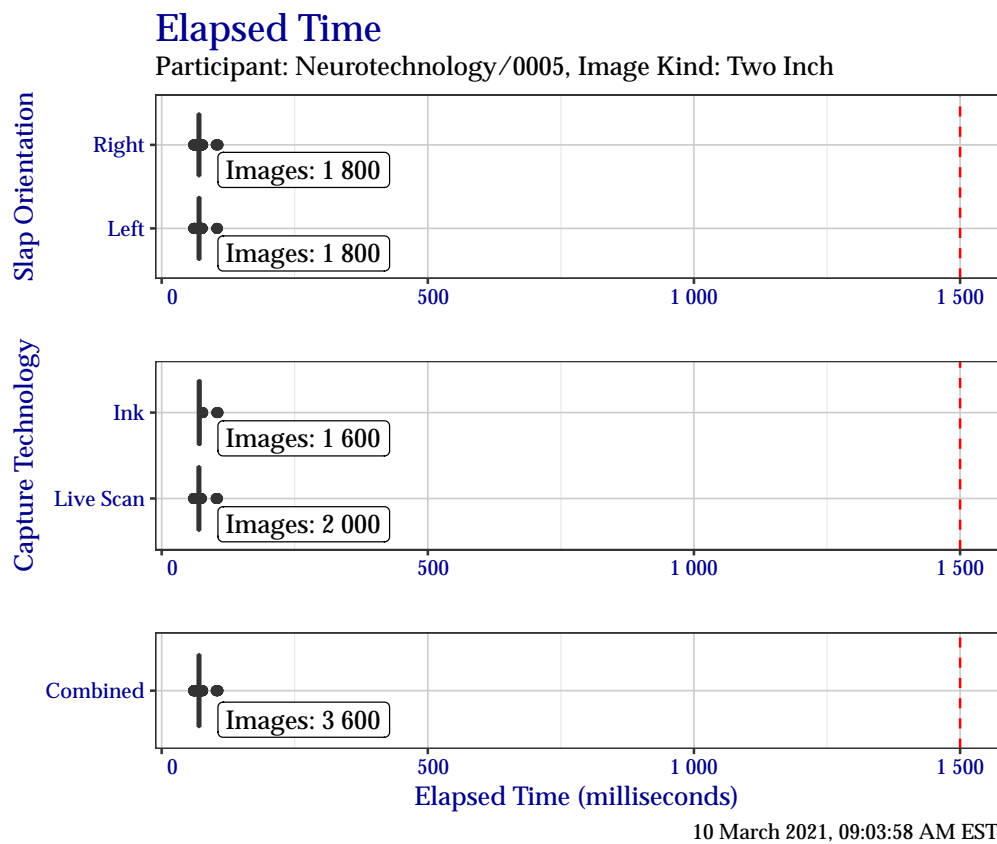


Figure 1: Box plots of elapsed time in milliseconds when segmenting the TwoInch timing test corpus, separated by slap orientation and capture technology.

Table 1: Elapsed time in milliseconds when segmenting the TwoInch timing test corpus, separated by slap orientation and capture technology.

|         | Right | Left | Live Scan | Ink | Combined |
|---------|-------|------|-----------|-----|----------|
| Minimum | 60    | 60   | 60        | 67  | 60       |
| 25%     | 70    | 70   | 70        | 70  | 70       |
| Median  | 70    | 70   | 70        | 70  | 70       |
| 75%     | 71    | 71   | 70        | 72  | 71       |
| Maximum | 106   | 105  | 105       | 106 | 106      |

## 2.2 Segmentation Centers and Dimensions

### 2.2.1 Segmentation Centers

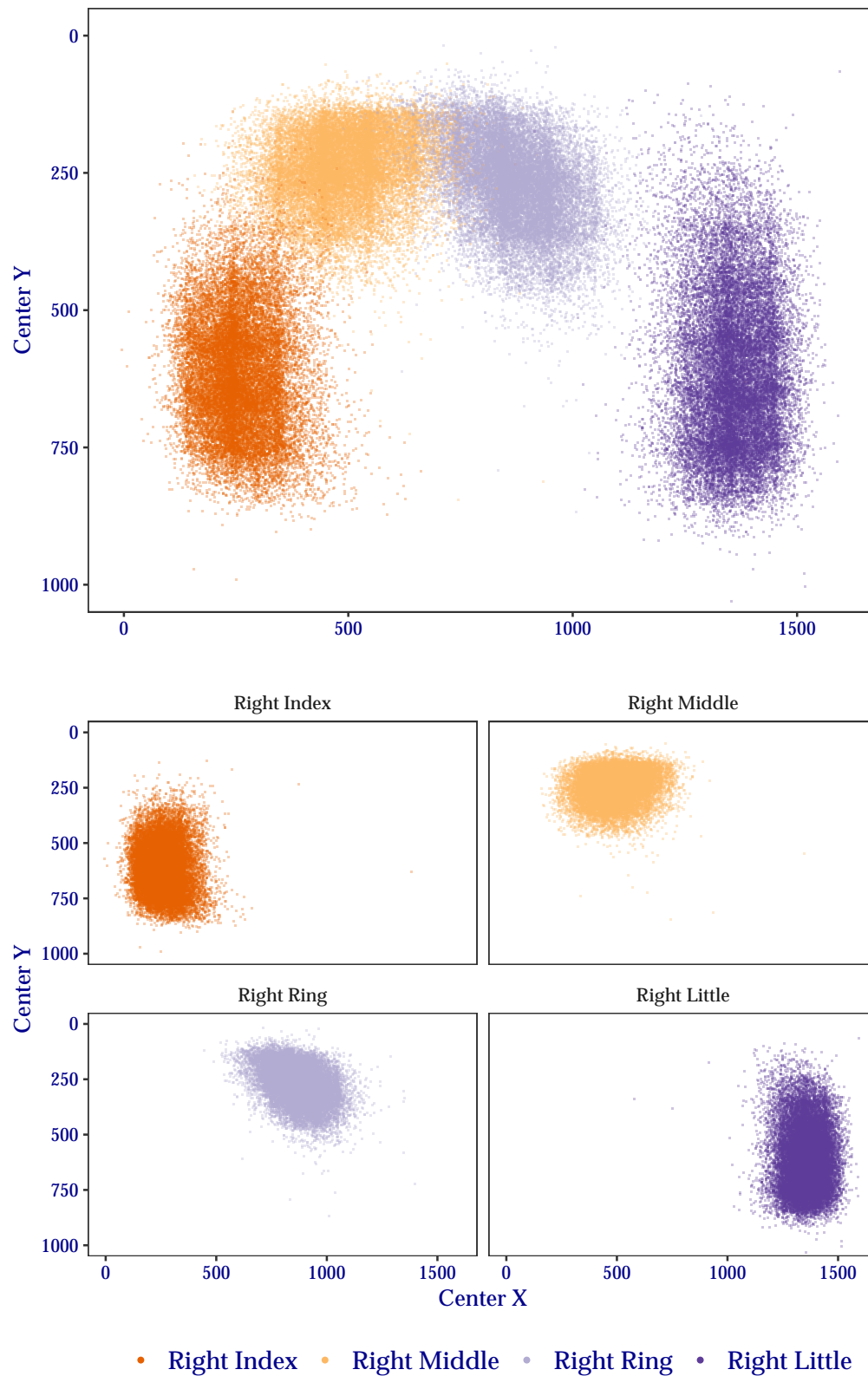
The plots in this section show the distribution of segmentation position centers  $(x, y)$  for TwoInch data. At the top of each figure is a combined plot for all finger positions of a given slap orientation. These figures are isolated in plots faceted at the bottom of the figure.

Plots of segmentation centers for the right hand TwoInch data are shown in Figure 2 and plots of segmentation centers for the left hand are shown in Figure 3. Blank lines that may appear in the plots are **not** rendering artifacts. Rather, they are indicative of image downsampling. Centers have been normalized to 500 pixels per inch.

Points in each plot are plotted with a semi-transparent opacity. This results in points of particular color appearing “darker” to indicate a higher frequency of the observed value, while “lighter” points indicate a lower observed frequency.

## Segmentation Position Centers

Participant: Neurotechnology/0005, FRGPs: 2, 3, 4, 5, Image Kind: Two Inch

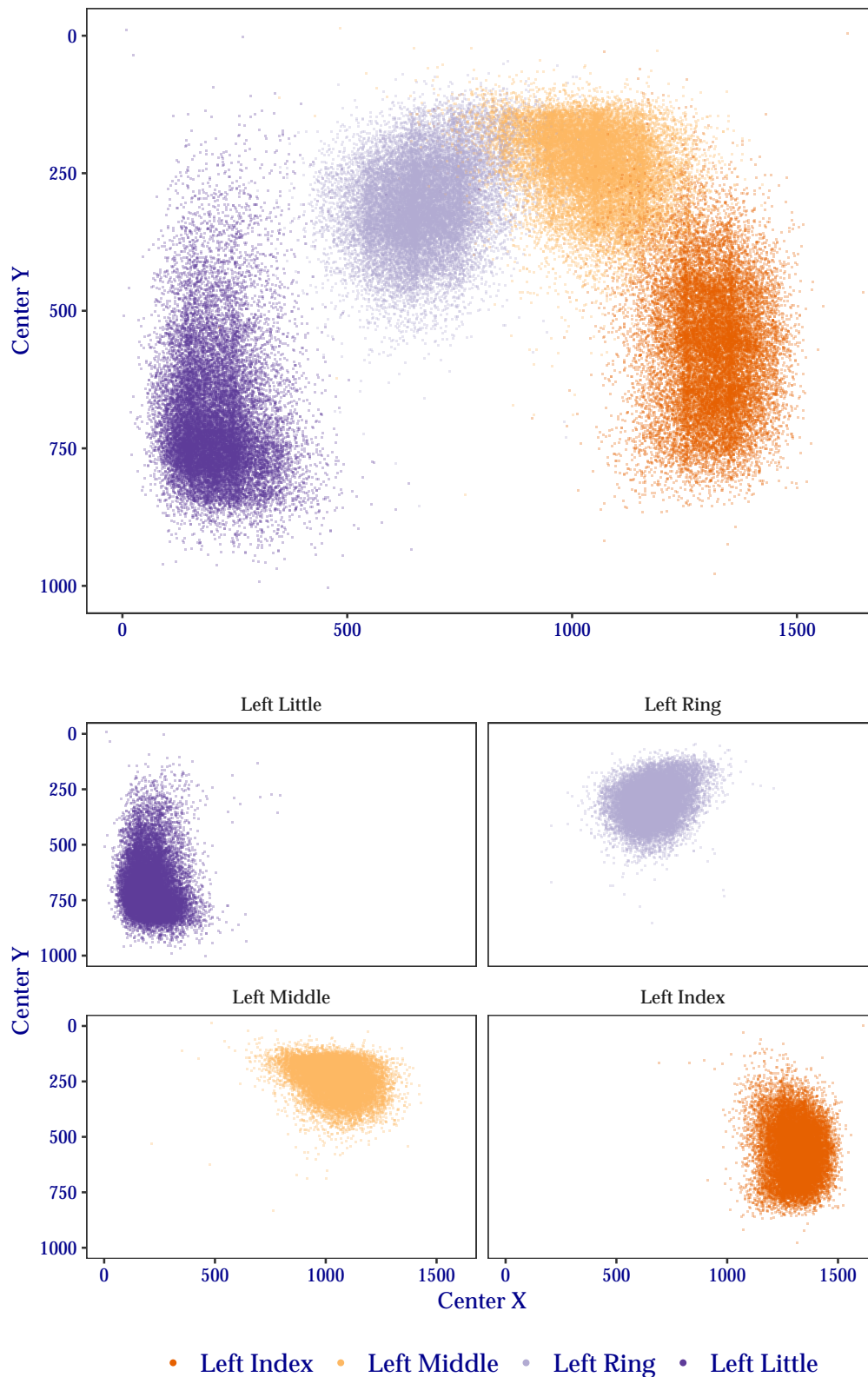


10 March 2021, 09:11:47 AM EST

Figure 2: Segmentation centers for right hand TwoInch data.

## Segmentation Position Centers

Participant: Neurotechnology/0005, FRGPs: 7, 8, 9, 10, Image Kind: Two Inch



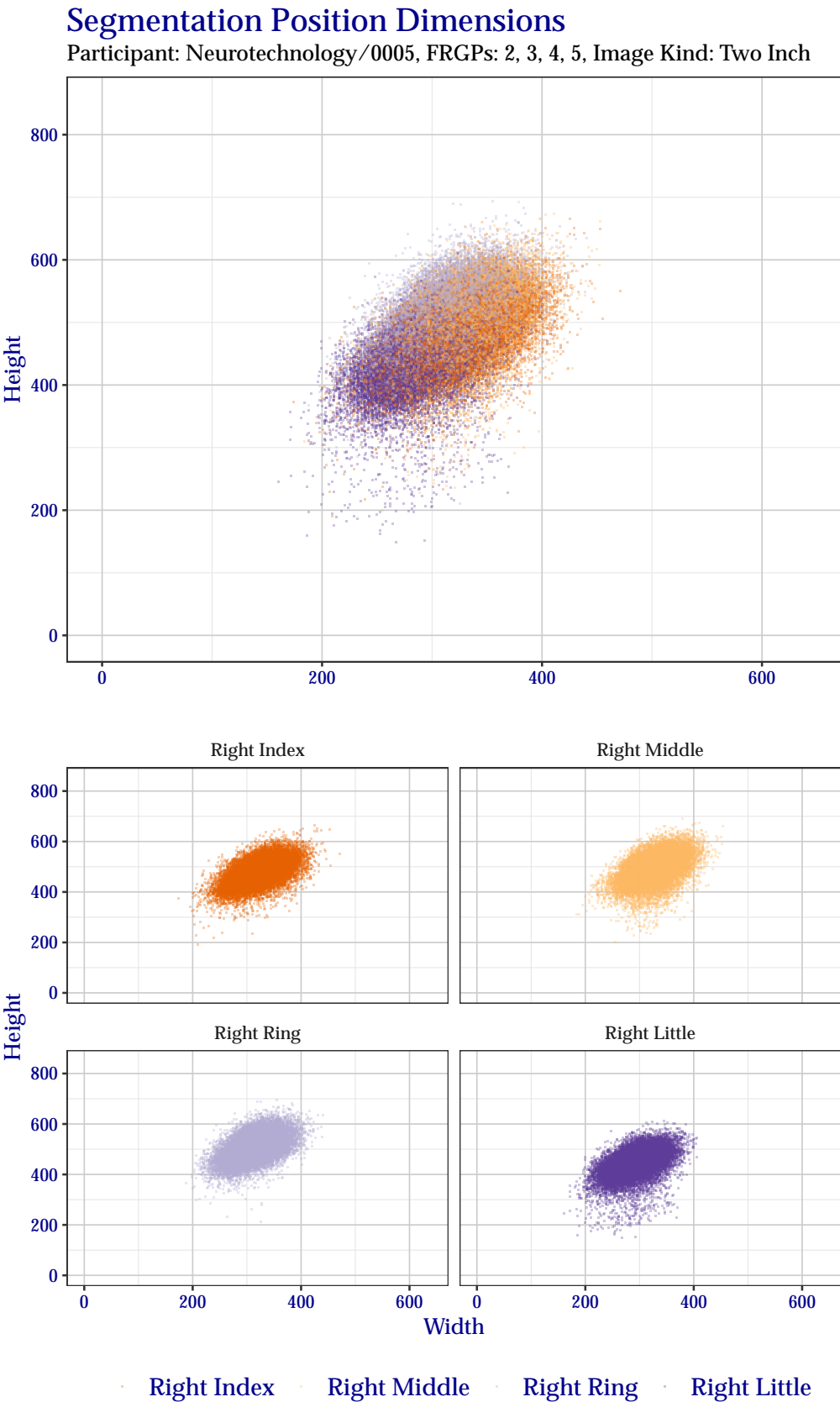
10 March 2021, 09:11:42 AM EST

Figure 3: Segmentation centers for left hand TwoInch data.

### 2.2.2 Segmentation Dimensions

The plots in this section show the distribution of segmentation position widths and heights for TwoInch data. At the top of each figure is a combined plot for all finger positions of a given slap orientation. These figures are isolated in plots faceted at the bottom of the figure.

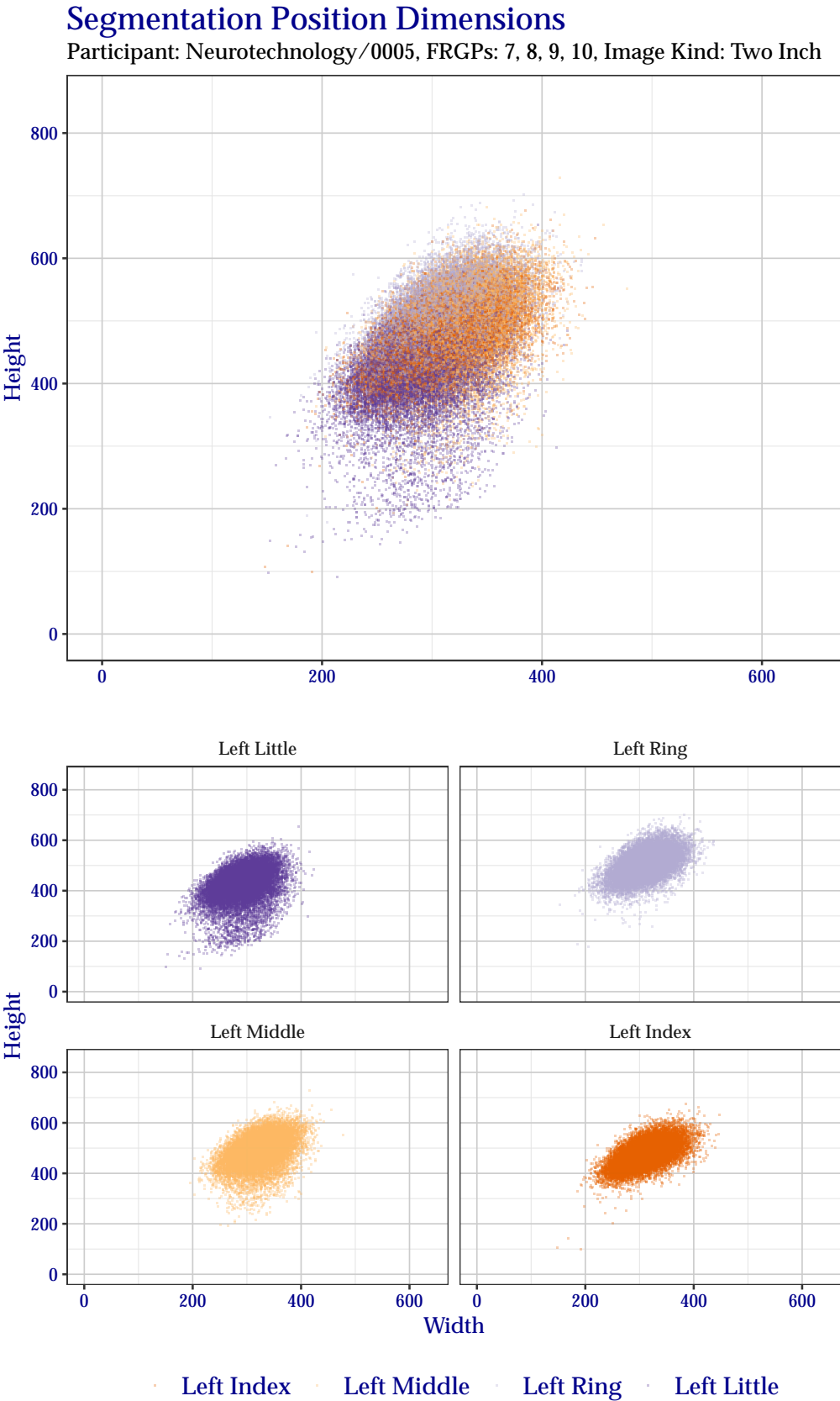
Plots of segmentation position dimensions for the right hand TwoInch data are shown in Figure 4 and the left hand in Figure 5. Blank lines that may appear in the plots are **not** rendering artifacts. Rather, they are indicative of image downsampling. Dimensions have been normalized to 500 pixels per inch.



10 March 2021, 09:11:56 AM EST

Figure 4: Segmentation position dimensions for right hand TwoInch data.





10 March 2021, 09:11:52 AM EST

Figure 5: Segmentation position dimensions for left hand TwoInch data.

## 2.3 Detailed Segmentation Statistics

This section shows detailed results of segmentation of TwoInch data. Values in each table are the percentage that the variable in the left-most column was correctly segmented.

Each table has three columns of percentages. The *Standard Scoring* column shows the percentage of correctly-segmented positions based on the scoring metrics defined in the SlapSeg III scoring document. The *Ignoring Bottom Y* column shows how the percentage would change if the threshold for the *bottom Y* coordinate of the segmentation position was ignored. Similarly, the *Ignoring Bottom X and Y* columns shows how the percentage would change if only the top, left, and right sides of the segmentation position were considered. These two supplemental columns are included because it has traditionally been difficult to determine the exact location of the distal interphalangeal joint.

Table 2 shows how successful Neurotechnology+0005 segmented fingers for each subject in the test corpus. Table 3 shows success for specific finger positions over the entire test corpus. Similarly, Table 4 shows success for segmenting the same finger position from both hands.

The remainder of the tables show success per subject when considering combinations of subsets of the fingers on each slap image. Table 5 shows success for combinations of all fingers, Table 6 for just the index and middle fingers, and Table 7 for all except the little finger.

Table 2: For each subject, the percentage that at least *Number of Fingers* fingers were correctly segmented, regardless of hand, for a maximum of eight correctly-segmented fingers. In *Standard Scoring*, scoring rules are followed exactly. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

| Number of Fingers | Standard Scoring | Ignoring Bottom Y | Ignoring Bottom X and Y |
|-------------------|------------------|-------------------|-------------------------|
| 1                 | 99.9             | 99.9              | 99.9                    |
| 2                 | 99.8             | 99.8              | 99.8                    |
| 3                 | 99.5             | 99.6              | 99.6                    |
| 4                 | 98.9             | 99.0              | 99.1                    |
| 5                 | 95.5             | 95.5              | 95.7                    |
| 6                 | 95.0             | 95.0              | 95.4                    |
| 7                 | 93.5             | 93.9              | 94.5                    |
| 8                 | 85.8             | 88.0              | 89.0                    |

Table 3: For all subjects, percentage that a particular friction ridge generalized position was correctly segmented. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

| Finger       | Standard Scoring | Ignoring Bottom Y | Ignoring Bottom X and Y |
|--------------|------------------|-------------------|-------------------------|
| <b>Right</b> |                  |                   |                         |
| Index        | 98.5             | 99.2              | 99.4                    |
| Middle       | 97.0             | 97.4              | 97.7                    |
| Ring         | 97.6             | 97.9              | 98.3                    |
| Little       | 98.2             | 98.4              | 99.2                    |
| <b>Left</b>  |                  |                   |                         |
| Index        | 98.7             | 99.1              | 99.1                    |
| Middle       | 97.9             | 98.2              | 98.3                    |
| Ring         | 98.3             | 98.8              | 98.9                    |
| Little       | 98.2             | 98.4              | 98.5                    |

Table 4: Percentage that a particular type of fingerprint was correctly segmented on *Either* or *Both* hands. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

| Fingers       | Standard Scoring | Ignoring Bottom Y | Ignoring Bottom X and Y |
|---------------|------------------|-------------------|-------------------------|
| <b>Index</b>  |                  |                   |                         |
| Either        | 99.5             | 99.5              | 99.6                    |
| Both          | 93.5             | 94.4              | 94.7                    |
| <b>Middle</b> |                  |                   |                         |
| Either        | 99.4             | 99.5              | 99.6                    |
| Both          | 91.4             | 92.0              | 92.4                    |
| <b>Ring</b>   |                  |                   |                         |
| Either        | 99.5             | 99.6              | 99.7                    |
| Both          | 92.4             | 93.2              | 93.6                    |
| <b>Little</b> |                  |                   |                         |
| Either        | 99.4             | 99.4              | 99.5                    |
| Both          | 92.6             | 93.1              | 93.9                    |

Table 5: Percentage of segmentation success by hand for combinations of all eight fingers of a TwoInch slap. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

| Fingers        | Standard Scoring | Ignoring Bottom Y | Ignoring Bottom X and Y |
|----------------|------------------|-------------------|-------------------------|
| <b>Right</b>   |                  |                   |                         |
| Any            | 99.8             | 99.8              | 99.9                    |
| At Least Two   | 99.5             | 99.6              | 99.8                    |
| At Least Three | 98.8             | 98.9              | 99.4                    |
| All Four       | 93.2             | 94.6              | 95.6                    |
| <b>Left</b>    |                  |                   |                         |
| Any            | 99.8             | 99.8              | 99.8                    |
| At Least Two   | 99.5             | 99.5              | 99.6                    |
| At Least Three | 98.9             | 99.0              | 99.1                    |
| All Four       | 94.9             | 96.1              | 96.3                    |

Table 6: Percentage of segmentation success by hand when only considering combinations of index and middle fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

| Fingers                | Standard Scoring | Ignoring Bottom Y | Ignoring Bottom X and Y |
|------------------------|------------------|-------------------|-------------------------|
| <b>Right</b>           |                  |                   |                         |
| Either Index or Middle | 99.6             | 99.6              | 99.8                    |
| Both Index and Middle  | 95.9             | 96.9              | 97.4                    |
| <b>Left</b>            |                  |                   |                         |
| Either Index or Middle | 99.5             | 99.6              | 99.6                    |
| Both Index and Middle  | 97.1             | 97.7              | 97.8                    |

Table 7: Percentage of segmentation success by hand when only considering combinations of index, middle, and ring fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates.

| Fingers      | Standard Scoring | Ignoring Bottom Y | Ignoring Bottom X and Y |
|--------------|------------------|-------------------|-------------------------|
| <b>Right</b> |                  |                   |                         |
| Any          | 99.7             | 99.7              | 99.9                    |
| At Least Two | 99.1             | 99.2              | 99.5                    |
| All Three    | 94.3             | 95.5              | 96.1                    |
| <b>Left</b>  |                  |                   |                         |
| Any          | 99.7             | 99.8              | 99.8                    |
| At Least Two | 99.2             | 99.3              | 99.4                    |
| All Three    | 96.0             | 97.0              | 97.1                    |

## 2.4 Handling Troublesome Images

### 2.4.1 Capture Failures

Segmentation algorithms may refuse to process an image. This may happen for a technical reason (e.g., the algorithm cannot parse the image data), or for a practical reason (e.g., the hand in the image is placed incorrectly). These failure scenarios are the result of capturing improper image data. In these types of scenarios, it is important to examine the cause of the failure. With many live scan capture setups, segmentation is performed immediately after capture. If an algorithm can detect that it won't be able to segment an image due to a technical or practical issue, it can alert the operator to perform a recapture before the subject leaves.

The SlapSeg III API encourages algorithms to identify these failure reasons by specifying pre-defined *deficiencies* in the image. Algorithms should attempt segmentation even if an image deficiency is encountered if at all possible. Note that SlapSeg III *guarantees* well-formed image data, so failures to parse are **not** an indicator of the data provided.

Neurotechnology+0005 did **not** report any capture failures.

#### 2.4.1.1 Recovery

When encountering a segmentation failure, SlapSeg III algorithms are encouraged to provide a *best-effort* segmentation when possible. In some cases, that best-effort may be correct, which reduces the amount of images that need to be manually adjudicated by an operator.

Neurotechnology+0005 did not attempt any recovery segmentations.

### 2.4.2 Segmentation Failures

Even if an algorithm accepts an image for processing, it can still fail to process one or more fingers from the image, regardless of if the algorithm requested a recapture and provided best-effort segmentation.

The SlapSeg III API allows algorithms to communicate reasons for failure to process these fingers. In some cases, the distal phalanx in question might not be present in the image due to amputation or being placed outside the platen's capture area. It is imperative that the segmentation algorithm correctly report this as failing to segment the correct friction ridge generalized position without disrupting the sequence of valid positions present in the image. This can help prompt an operator to recapture or record additional information about the subject.

In SlapSeg III, a number of images are missing fingers or otherwise have fingers that will not be able to be segmented. Reasons for segmentation failures reported by Neurotechnology+0005 are enumerated in Table 8.

Table 8: Count of self-reported segmentation failure reasoning.

| Failure Reason                  | Fingers |
|---------------------------------|---------|
| Finger Not Found                | 180     |
| Finger Found, but Can't Segment | 0       |
| Vendor Defined                  | 0       |

#### 2.4.3 Identifying Missing Fingers

A small portion of the test corpus in SlapSeg III are missing fingers. Table 9 shows how successful Neurotechnology+0005 was in correctly determining if a finger was missing. The *Missed* row shows when a segmentation position was returned for a missing finger. All possible failure reasons are enumerated, but are

not considered *Correctly Identified* because the algorithm specified failure for a reason other than the finger not being found.

Table 9: Performance of Neurotechnology+0005 at detecting fingers missing from an image.

| Result   | Percentage |
|--|------------|
| Missed   | 21.9       |
| Correctly Identified                           | 78.1       |
| Other Failure: Finger Found, but Can't Segment | 0.0        |
| Other Failure: Vendor Defined                  | 0.0        |
| Other Failure: Segmentation Not Attempted      | 0.0        |

#### 2.4.4 Sequence Error

Sequence error occurs when a fingerprint is segmented from an image but assigned an incorrect finger position (e.g., segmenting a right middle finger but labeling it a right index finger). Table 10 shows cases in which a segmentation position was returned that matched a ground truth segmentation position for a different finger in the same image.

Table 10: Percentage of images in the dataset where one or more segmentation positions correctly matched an incorrect finger position within the same image, indicating sequence error.

| Hand     | Standard Scoring | Ignoring Bottom Y | Ignoring Bottom X and Y |
|----------|------------------|-------------------|-------------------------|
| Left     | 0.10             | 0.10              | 0.10                    |
| Right    | 0.05             | 0.05              | 0.05                    |
| Combined | 0.07             | 0.07              | 0.07                    |

## 2.5 Determining Orientation

An *optional* portion of the SlapSeg III API asked participants to determine the hand orientation of an image. Participants were provided the kind (e.g., Tenprint card) and capture technology (e.g., ink), and needed to determine whether the image was of the left or right hand.

**Overall Two Inch accuracy:** 99.9%

Table 11: Percentage of accuracy when determining hand orientation of a two inch image. The first column indicates the true hand orientation. Subsequent columns indicate the percentage of the time in which the indicated hand orientation was hypothesized.

|       | Left        | Right       |
|-------|-------------|-------------|
| Left  | <b>99.9</b> | 0.1         |
| Right | 0.1         | <b>99.9</b> |

## A Tenprint Cards (“TwoInch” Data)

### A.1 Bootstrap Confidence for Segmentation Statistics

This section shows the same detailed results of segmentation of TwoInch data from Section 2.3, but with an added bootstrap confidence interval. For each observation, a bootstrap routine with 1 000 replicates was run, and a 95 % confidence interval extracted. The lower and upper confidence from that confidence interval are printed in each column within square brackets.

In Table 12, results are shown of how successful Neurotechnology+0005 segmented fingers for each subject in the test corpus. Table 13 shows success for specific finger positions over the entire test corpus. Similarly, Table 14 shows success for segmenting the same finger position from both hands.

The remainder of the tables show success per subject when considering combinations of subsets of the fingers in each slap image. Table 15 shows success for combinations of all fingers, Table 17 for the all except the little finger, and Table 16 for just the index and middle fingers.

Table 12: For each subject, the percentage that at least *Number of Fingers* fingers were correctly segmented, regardless of hand, for a maximum of eight correctly-segmented fingers. In *Standard Scoring*, scoring rules are followed exactly. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

| Number of Fingers | Standard Scoring  | Ignoring Bottom Y | Ignoring Bottom X and Y |
|-------------------|-------------------|-------------------|-------------------------|
| 1                 | 99.9 [99.8, 99.9] | 99.9 [99.8, 99.9] | 99.9 [99.8, 100.0]      |
| 2                 | 99.8 [99.7, 99.8] | 99.8 [99.7, 99.9] | 99.8 [99.7, 99.9]       |
| 3                 | 99.5 [99.4, 99.6] | 99.6 [99.4, 99.7] | 99.6 [99.5, 99.7]       |
| 4                 | 98.9 [98.8, 99.1] | 99.0 [98.8, 99.2] | 99.1 [98.9, 99.3]       |
| 5                 | 95.5 [95.1, 95.8] | 95.5 [95.1, 95.8] | 95.7 [95.3, 96.0]       |
| 6                 | 95.0 [94.6, 95.3] | 95.0 [94.6, 95.4] | 95.4 [95.0, 95.7]       |
| 7                 | 93.5 [93.1, 93.9] | 93.9 [93.5, 94.3] | 94.5 [94.0, 94.9]       |
| 8                 | 85.8 [85.2, 86.4] | 88.0 [87.4, 88.6] | 89.0 [88.4, 89.5]       |

Table 13: For all subjects, Percentage that a particular friction ridge generalized position was correctly segmented. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

| Finger       | Standard Scoring  | Ignoring Bottom Y | Ignoring Bottom X and Y |
|--------------|-------------------|-------------------|-------------------------|
| <b>Right</b> |                   |                   |                         |
| Index        | 98.5 [98.3, 98.6] | 99.2 [99.0, 99.3] | 99.4 [99.3, 99.5]       |
| Middle       | 97.0 [96.8, 97.2] | 97.4 [97.2, 97.6] | 97.7 [97.6, 97.9]       |
| Ring         | 97.6 [97.4, 97.8] | 97.9 [97.7, 98.1] | 98.3 [98.1, 98.5]       |
| Little       | 98.2 [98.0, 98.3] | 98.4 [98.3, 98.6] | 99.2 [99.0, 99.3]       |
| <b>Left</b>  |                   |                   |                         |
| Index        | 98.7 [98.6, 98.9] | 99.1 [98.9, 99.2] | 99.1 [99.0, 99.2]       |
| Middle       | 97.9 [97.7, 98.1] | 98.2 [98.0, 98.4] | 98.3 [98.1, 98.4]       |
| Ring         | 98.3 [98.1, 98.5] | 98.8 [98.6, 98.9] | 98.9 [98.7, 99.0]       |
| Little       | 98.2 [98.0, 98.4] | 98.4 [98.2, 98.6] | 98.5 [98.4, 98.7]       |



Table 14: Percentage that a particular type of fingerprint was correctly segmented on *Either* or *Both* hands. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

| Fingers       | Standard Scoring  | Ignoring Bottom Y | Ignoring Bottom X and Y |
|---------------|-------------------|-------------------|-------------------------|
| <b>Index</b>  |                   |                   |                         |
| Either        | 99.5 [99.4, 99.6] | 99.5 [99.4, 99.6] | 99.6 [99.4, 99.7]       |
| Both          | 93.5 [93.1, 93.9] | 94.4 [94.0, 94.8] | 94.7 [94.3, 95.1]       |
| <b>Middle</b> |                   |                   |                         |
| Either        | 99.4 [99.3, 99.6] | 99.5 [99.4, 99.6] | 99.6 [99.5, 99.7]       |
| Both          | 91.4 [90.9, 91.9] | 92.0 [91.6, 92.5] | 92.4 [91.9, 92.8]       |
| <b>Ring</b>   |                   |                   |                         |
| Either        | 99.5 [99.4, 99.6] | 99.6 [99.5, 99.7] | 99.7 [99.6, 99.8]       |
| Both          | 92.4 [91.9, 92.9] | 93.2 [92.7, 93.6] | 93.6 [93.2, 94.0]       |
| <b>Little</b> |                   |                   |                         |
| Either        | 99.4 [99.2, 99.5] | 99.4 [99.3, 99.5] | 99.5 [99.3, 99.6]       |
| Both          | 92.6 [92.2, 93.1] | 93.1 [92.6, 93.5] | 93.9 [93.5, 94.4]       |

Table 15: Percentage of segmentation success by hand for combinations of all eight fingers of a TwoInch slap. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

| Fingers        | Standard Scoring  | Ignoring Bottom Y | Ignoring Bottom X and Y |
|----------------|-------------------|-------------------|-------------------------|
| <b>Right</b>   |                   |                   |                         |
| Any            | 99.8 [99.8, 99.8] | 99.8 [99.8, 99.8] | 99.9 [99.8, 99.9]       |
| At Least Two   | 99.5 [99.4, 99.6] | 99.6 [99.5, 99.6] | 99.8 [99.6, 99.8]       |
| At Least Three | 98.8 [98.7, 98.9] | 98.9 [98.9, 99.1] | 99.4 [99.2, 99.3]       |
| All Four       | 93.2 [93.8, 94.2] | 94.6 [95.1, 95.5] | 95.6 [95.7, 96.1]       |
| <b>Left</b>    |                   |                   |                         |
| Any            | 99.8 [99.8, 99.8] | 99.8 [99.8, 99.8] | 99.8 [99.8, 99.9]       |
| At Least Two   | 99.5 [99.4, 99.6] | 99.5 [99.5, 99.6] | 99.6 [99.6, 99.8]       |
| At Least Three | 98.9 [98.7, 98.9] | 99.0 [98.9, 99.1] | 99.1 [99.2, 99.3]       |
| All Four       | 94.9 [93.8, 94.2] | 96.1 [95.1, 95.5] | 96.3 [95.7, 96.1]       |

Table 16: Percentage of segmentation success by hand when only considering combinations of index and middle fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

| Fingers                | Standard Scoring  | Ignoring Bottom Y | Ignoring Bottom X and Y |
|------------------------|-------------------|-------------------|-------------------------|
| <b>Right</b>           |                   |                   |                         |
| Either Index or Middle | 99.6 [99.5, 99.6] | 99.6 [99.5, 99.7] | 99.8 [99.7, 99.8]       |
| Both Index and Middle  | 95.9 [96.3, 96.6] | 96.9 [97.1, 97.4] | 97.4 [97.4, 97.7]       |
| <b>Left</b>            |                   |                   |                         |
| Either Index or Middle | 99.5 [99.5, 99.6] | 99.6 [99.5, 99.7] | 99.6 [99.7, 99.8]       |
| Both Index and Middle  | 97.1 [96.3, 96.6] | 97.7 [97.1, 97.4] | 97.8 [97.4, 97.7]       |

Table 17: Percentage of segmentation success by hand when only considering combinations of index, middle, and ring fingers. In *Ignoring Bottom Y*, the bottom left and bottom right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and top right coordinates. Values in square brackets represent a 95 % confidence interval after bootstrapping with 1 000 replicates.

| Fingers      | Standard Scoring  | Ignoring Bottom Y | Ignoring Bottom X and Y |
|--------------|-------------------|-------------------|-------------------------|
| <b>Right</b> |                   |                   |                         |
| Any          | 99.7 [99.7, 99.8] | 99.7 [99.7, 99.8] | 99.9 [99.8, 99.9]       |
| At Least Two | 99.1 [99.0, 99.2] | 99.2 [99.2, 99.3] | 99.5 [99.4, 99.5]       |
| All Three    | 94.3 [94.8, 95.3] | 95.5 [96.0, 96.4] | 96.1 [96.4, 96.7]       |
| <b>Left</b>  |                   |                   |                         |
| Any          | 99.7 [99.7, 99.8] | 99.8 [99.7, 99.8] | 99.8 [99.8, 99.9]       |
| At Least Two | 99.2 [99.0, 99.2] | 99.3 [99.2, 99.3] | 99.4 [99.4, 99.5]       |
| All Three    | 96.0 [94.8, 95.3] | 97.0 [96.0, 96.4] | 97.1 [96.4, 96.7]       |

## A.2 Jaccard Index

Table 18: For each subject, the percentage that at least *Number of Fingers* fingers were segmented with a Jaccard index in the indicated range.

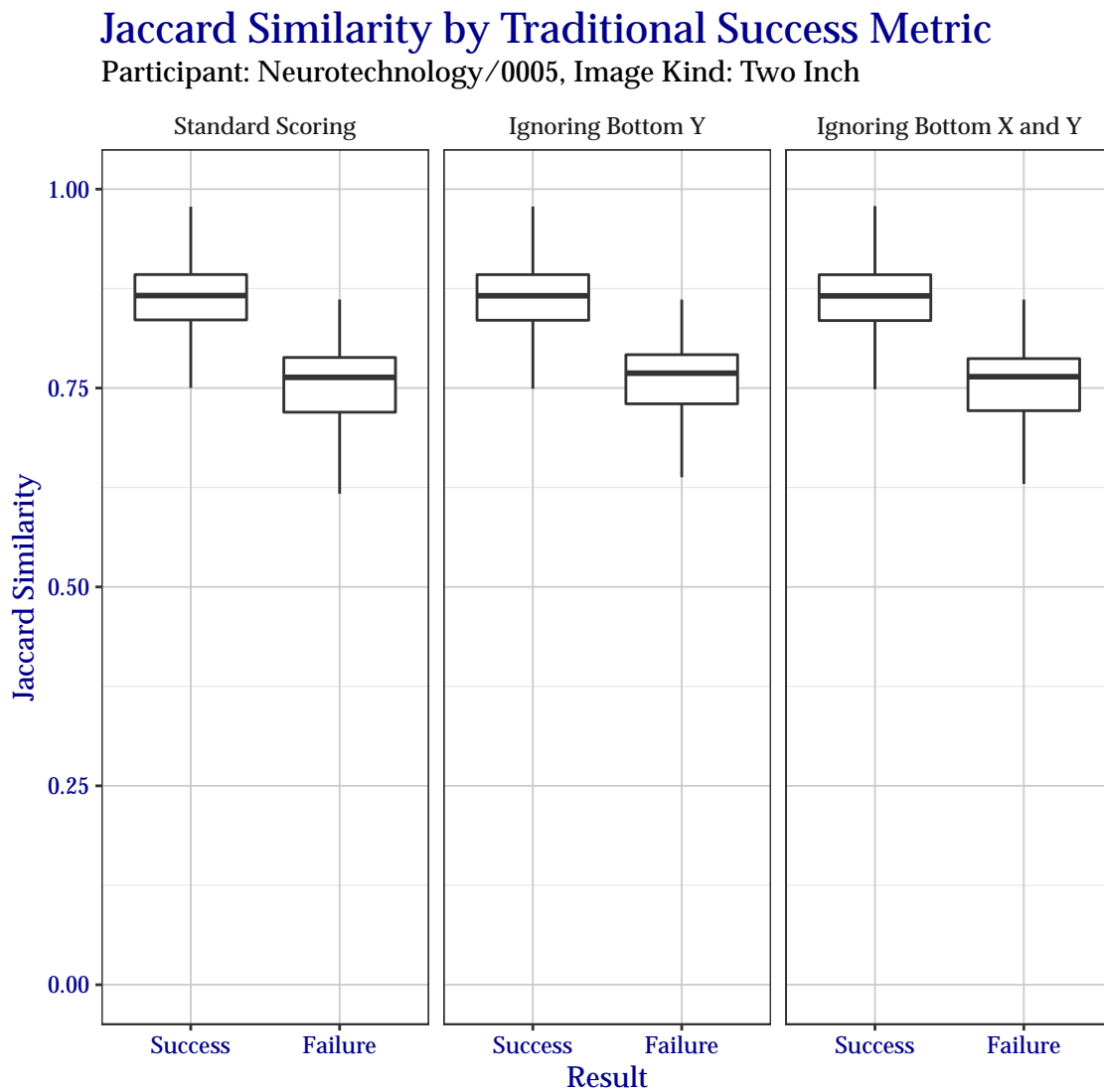
| Number of Fingers | $\geq 0.5$ | $\geq 0.6$ | $\geq 0.7$ | $\geq 0.8$ | $\geq 0.9$ | $\geq 0.95$ | $\geq 0.98$ |
|-------------------|------------|------------|------------|------------|------------|-------------|-------------|
| 1                 | 99.9       | 99.9       | 99.9       | 99.9       | 67.0       | 5.9         | 0.1         |
| 2                 | 99.9       | 99.9       | 99.9       | 99.6       | 42.1       | 0.7         | 0.0         |
| 3                 | 99.8       | 99.8       | 99.7       | 99.0       | 23.3       | 0.1         | 0.0         |
| 4                 | 99.5       | 99.4       | 99.2       | 96.9       | 10.6       | 0.0         | 0.0         |
| 5                 | 95.9       | 95.9       | 95.8       | 92.2       | 3.7        | 0           | 0           |
| 6                 | 95.8       | 95.8       | 95.8       | 85.8       | 1.2        | 0           | 0           |
| 7                 | 95.8       | 95.7       | 95.0       | 72.9       | 0.2        | 0           | 0           |
| 8                 | 95.2       | 94.6       | 89.6       | 47.2       | 0.0        | 0           | 0           |

Table 19: For all subjects, percentage that a particular friction ridge generalized position was segmented with a Jaccard index in the indicated range.

| Finger       | 0-0.5 | 0.5-0.6 | 0.6-0.7 | 0.7-0.8 | 0.8-0.9 | 0.9-1.0 |
|--------------|-------|---------|---------|---------|---------|---------|
| <b>Right</b> |       |         |         |         |         |         |
| Index        | 0.2   | 0.0     | 0.3     | 6.3     | 70.4    | 22.8    |
| Middle       | 0.2   | 0.0     | 0.2     | 7.1     | 69.8    | 22.7    |
| Ring         | 0.1   | 0.0     | 0.3     | 6.0     | 74.3    | 19.3    |
| Little       | 0.2   | 0.0     | 0.8     | 8.6     | 66.6    | 23.8    |
| <b>Left</b>  |       |         |         |         |         |         |
| Index        | 0.2   | 0.0     | 0.4     | 9.9     | 71.4    | 18.1    |
| Middle       | 0.3   | 0.0     | 0.8     | 14.2    | 72.2    | 12.5    |
| Ring         | 0.2   | 0.2     | 1.0     | 12.0    | 72.6    | 14.0    |
| Little       | 0.3   | 0.2     | 1.5     | 17.3    | 66.3    | 14.4    |

Table 20: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of all eight fingers of a TwoInch slap.

| Fingers        | $\geq 0.5$ | $\geq 0.6$ | $\geq 0.7$ | $\geq 0.8$ | $\geq 0.9$ | $\geq 0.95$ | $\geq 0.98$ |
|----------------|------------|------------|------------|------------|------------|-------------|-------------|
| <b>Right</b>   |            |            |            |            |            |             |             |
| Any            | 100.0      | 100.0      | 100.0      | 99.6       | 48.9       | 3.9         | 0.1         |
| At Least Two   | 99.9       | 99.9       | 99.9       | 98.9       | 25.9       | 0.5         | 0.0         |
| At Least Three | 99.9       | 99.9       | 99.9       | 95.1       | 11.0       | 0.1         | 0.0         |
| All Four       | 99.7       | 99.6       | 98.0       | 76.1       | 2.7        | 0.0         | 0.0         |
| <b>Left</b>    |            |            |            |            |            |             |             |
| Any            | 100.0      | 100.0      | 100.0      | 98.5       | 38.1       | 1.8         | 0.1         |
| At Least Two   | 99.9       | 99.9       | 99.8       | 94.4       | 15.4       | 0.1         | 0.0         |
| At Least Three | 99.8       | 99.8       | 99.5       | 85.8       | 4.8        | 0.0         | 0.0         |
| All Four       | 99.4       | 98.9       | 95.6       | 62.8       | 0.7        | 0.0         | 0.0         |



10 March 2021, 09:11:28 AM EST

Figure 6: Boxplot of Jaccard similarity indices as compared to the traditional success metrics. Outliers have been removed for clarity.

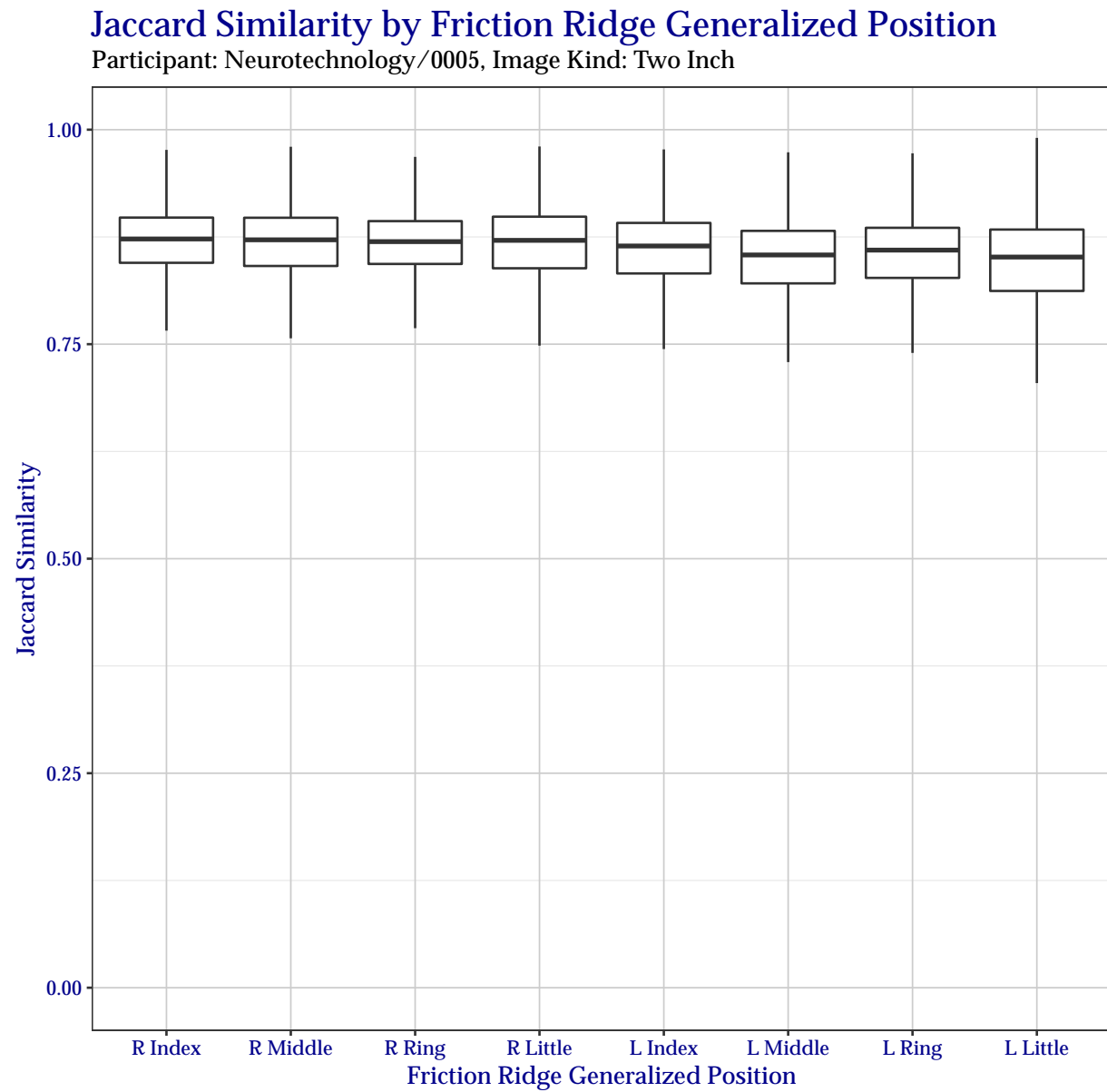


Figure 7: Boxplot of Jaccard similarity indices for each friction ridge generalized position. Outliers have been removed for clarity.

Table 21: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of index and middle fingers of a TwoInch slap.

| Fingers                | $\geq 0.5$ | $\geq 0.6$ | $\geq 0.7$ | $\geq 0.8$ | $\geq 0.9$ | $\geq 0.95$ | $\geq 0.98$ |
|------------------------|------------|------------|------------|------------|------------|-------------|-------------|
| <b>Right</b>           |            |            |            |            |            |             |             |
| Either Index or Middle | 99.9       | 99.9       | 99.9       | 98.8       | 35.7       | 2.2         | 0.0         |
| Both Index and Middle  | 99.8       | 99.8       | 99.2       | 87.0       | 9.8        | 0.1         | 0.0         |
| <b>Left</b>            |            |            |            |            |            |             |             |
| Either Index or Middle | 99.9       | 99.9       | 99.8       | 95.7       | 25.8       | 1.0         | 0.0         |
| Both Index and Middle  | 99.6       | 99.6       | 98.5       | 78.5       | 4.8        | 0.0         | 0.0         |

Table 22: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of index, middle, and ring fingers of a TwoInch slap.

| Fingers      | $\geq 0.5$ | $\geq 0.6$ | $\geq 0.7$ | $\geq 0.8$ | $\geq 0.9$ | $\geq 0.95$ | $\geq 0.98$ |
|--------------|------------|------------|------------|------------|------------|-------------|-------------|
| <b>Right</b> |            |            |            |            |            |             |             |
| Any          | 100.0      | 100.0      | 99.9       | 99.4       | 41.9       | 2.8         | 0.1         |
| At Least Two | 99.9       | 99.9       | 99.9       | 97.2       | 18.1       | 0.3         | 0.0         |
| All Three    | 99.8       | 99.7       | 98.9       | 82.7       | 4.8        | 0.0         | 0.0         |
| <b>Left</b>  |            |            |            |            |            |             |             |
| Any          | 100.0      | 100.0      | 99.9       | 97.5       | 32.3       | 1.3         | 0.1         |
| At Least Two | 99.9       | 99.9       | 99.6       | 90.5       | 10.4       | 0.0         | 0.0         |
| All Three    | 99.5       | 99.3       | 97.4       | 72.8       | 2.0        | 0.0         | 0.0         |