Neurotechnology+0009

Neurotechnology

Slap Fingerprint Segmentation Evaluation III

Last Updated: 15 November 2022

Contents

1 Participation Information

1.1 Names and Dates

- **Organization Name:** Neurotechnology
- **SlapSeg III Identifier:** `Neurotechnology+0009`
- **SlapSeg III API Version:** 1.2.0
- **Provided Marketing Name:** "MegaMatcher"
- **Application Date:** 25 July 2022
- **First Submission Date:** 28 July 2022 (as version `0009`)
- **Validation Date:** 28 July 2022
- **Completion Date:** 01 August 2022

1.2 Libraries

Filename	MD5 Checksum	Size
libMKLDNNPlugin.so	`baa88f42cbb37a7652b47bdf84b80468`	33 MB
libtbbmalloc.so.2	`192eb094618225d3038b0f81dc4eab33`	238 kB
libmkl_tiny.so	`78499860662633254ebdff4168be8b60`	25 MB
libslapsegiii_Neurotechnology_0009.so	`d36a6f841c4d9200f91e6823682b69a1`	12 MB
libinference_engine.so	`15cc63a10afaaff6e52176770cf21c9a`	2 MB
libiomp5.so	`2de0b9ab4a5b58d0174de20891b78775`	2 MB
libinference_engine_transformations.so	`c47c774933ff44d48356f445271c41e6`	4 MB
SlapSeg3.ndf	`5b58271afe6f1e4516697080c6175806`	10 MB
libinference_engine_lp_transformations.so	`3ca1e4b90b15929ec9a2bca4a30426a0`	2 MB
libtbb.so.2	`70eea2fff6bebad5e2fcd00c6a7e0d9b`	416 kB
libngraph.so	`e080ec7ab44d120525a01a84f755fbf5`	8 MB

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. Times are measured by running a single process on an isolated compute node equipped with an Intel Gold 6254 CPU (submissions received prior to February 2022 were timed with a Intel Xeon E5-4650 CPU).

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.

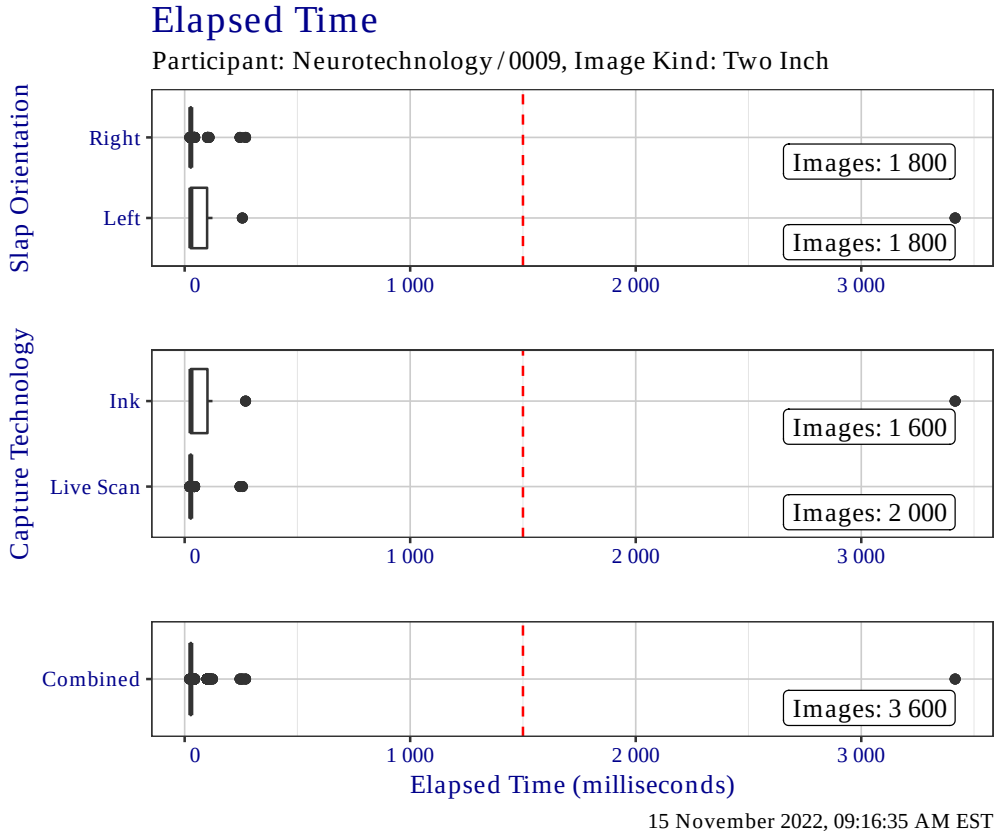

Figure 1: Box plots of elapsed time in milliseconds when segmenting the TwoInch timing test corpus, separated by slap orientation and capture technology.

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	23	23	23	25	23
25%	27	27	27	27	27
Median	27	27	27	28	27
75%	28	100	27	101	28
Maximum	270	3 416	256	3 416	3 416

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.

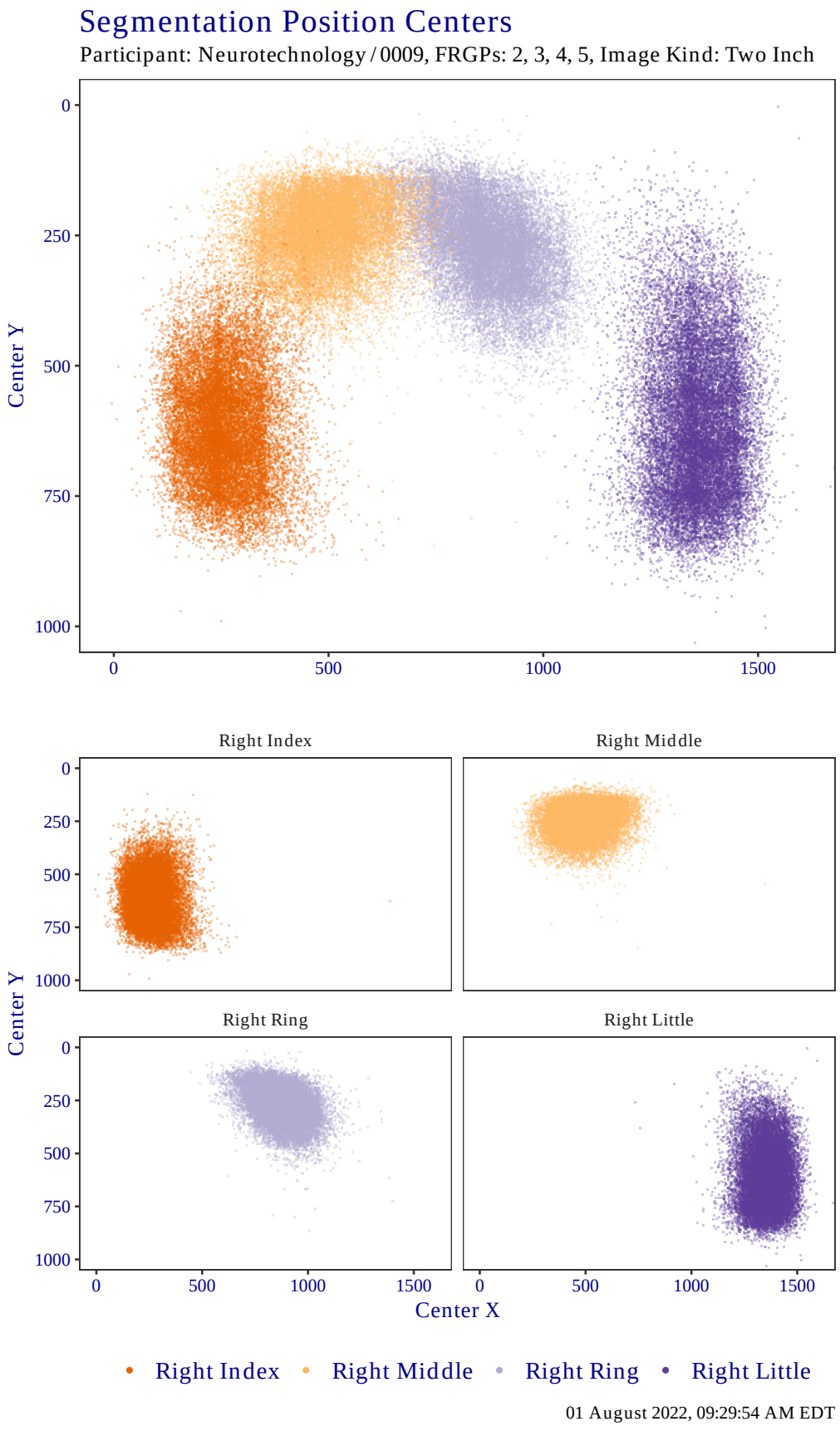

Figure 2: Segmentation centers for right hand TwoInch data.

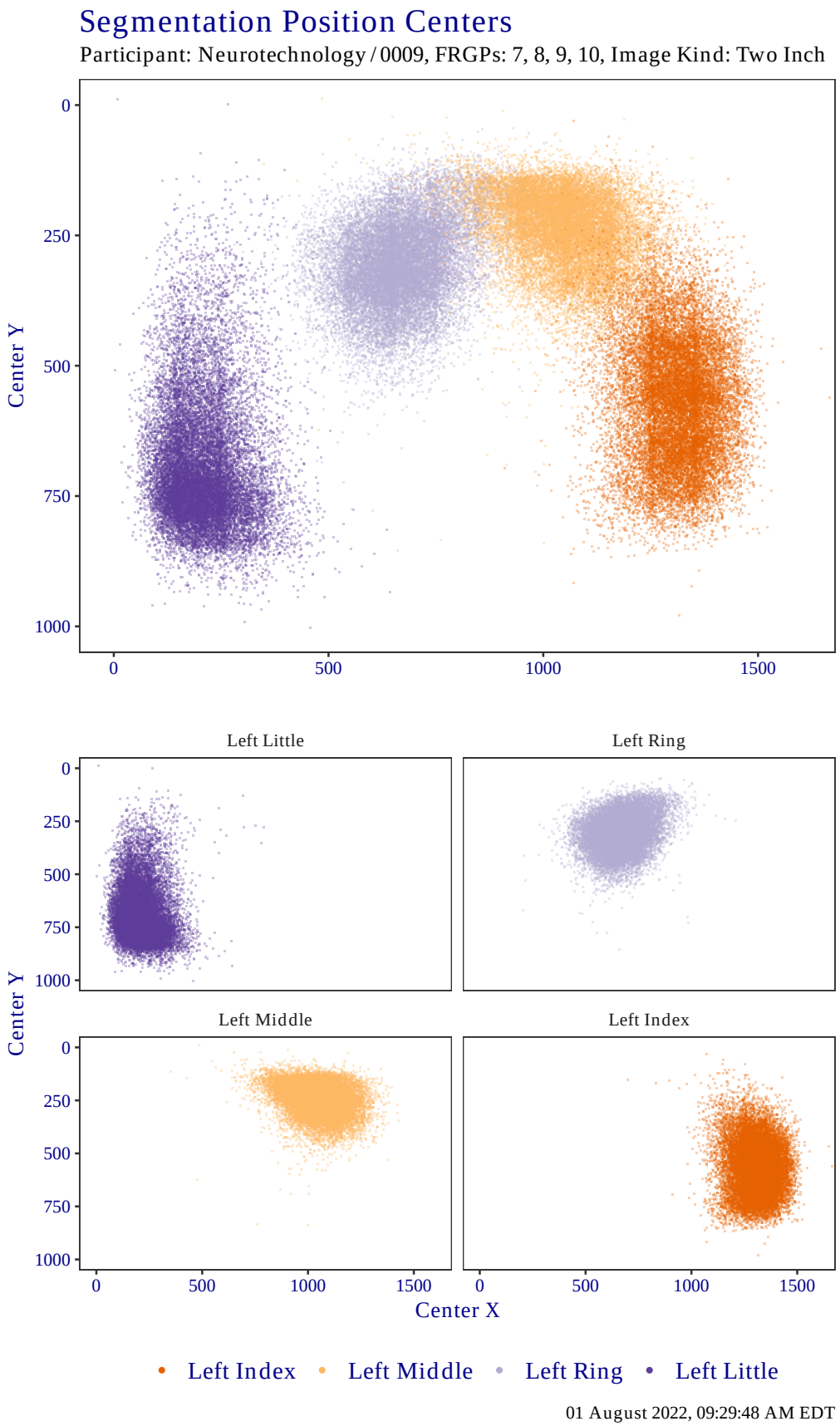

Figure 3: Segmentation centers for left hand TwoInch data.

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.

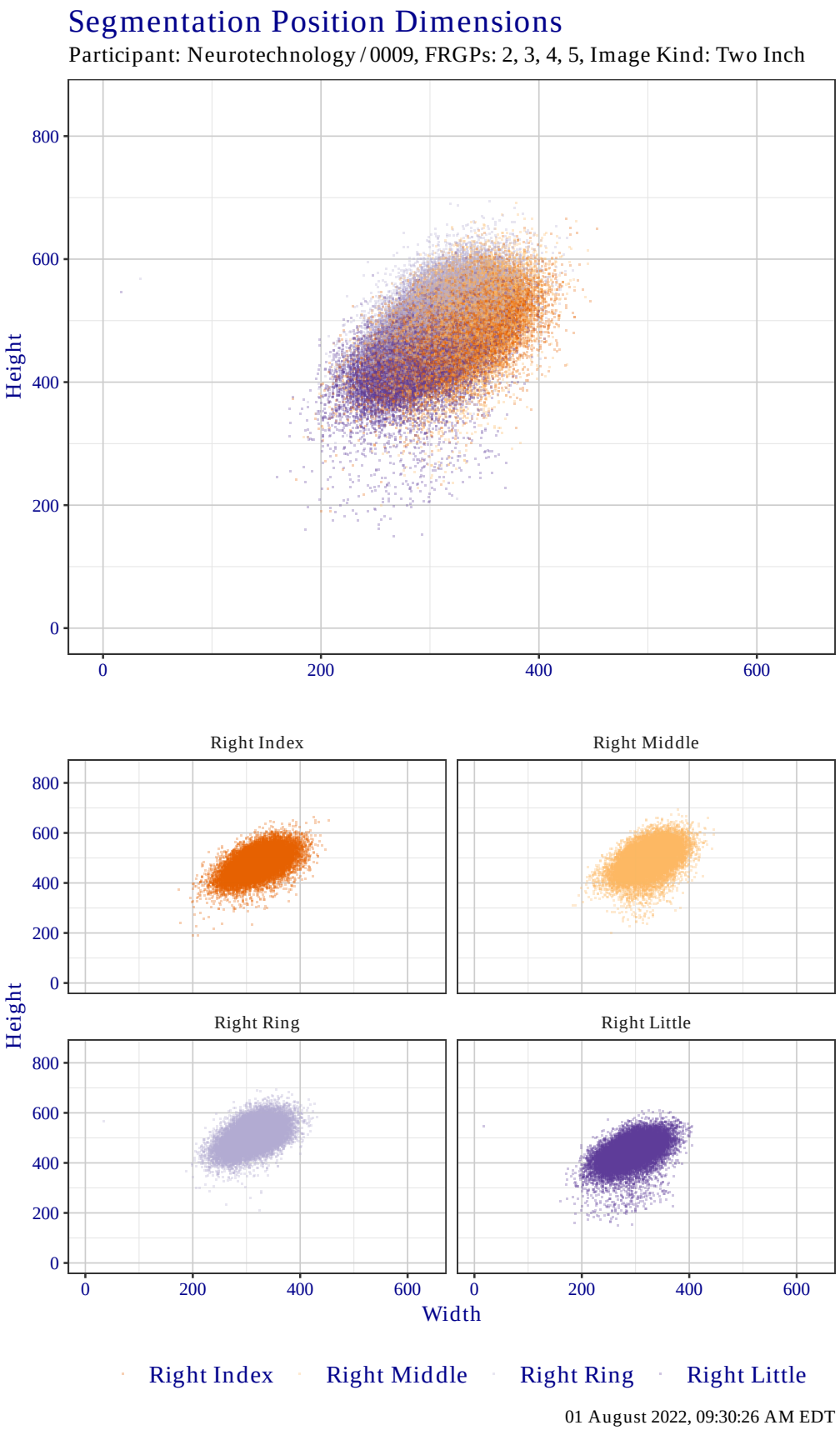

Figure 4: Segmentation position dimensions for right hand TwoInch data.

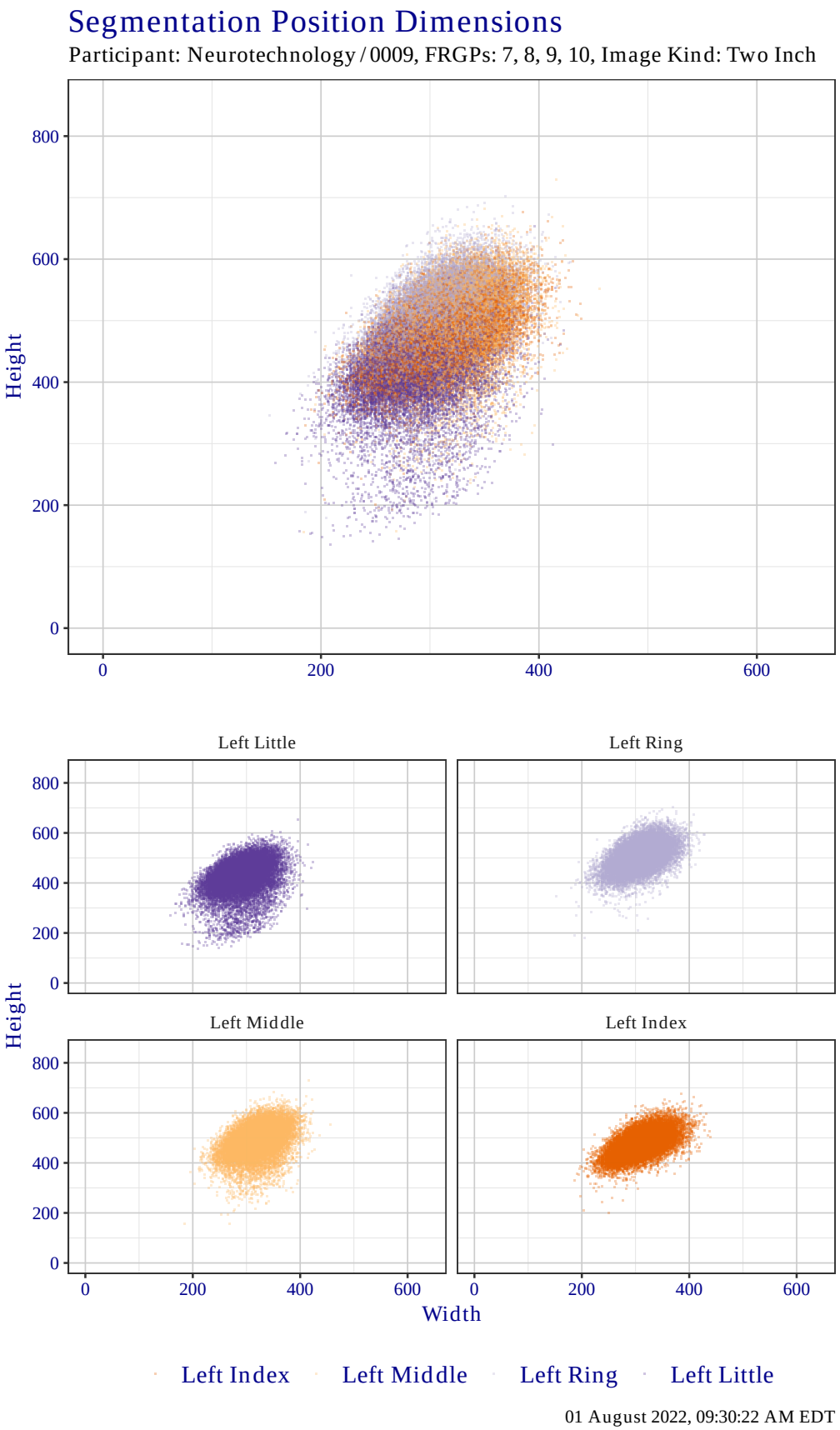

Figure 5: Segmentation position dimensions for left hand TwoInch data.

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+0009 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	99.5	99.6
4	98.9	99.0	99.2
5	95.4	95.4	95.7
6	94.7	94.8	95.3
7	93.1	93.5	94.3
8	85.2	87.4	88.6

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
Right			
Index	98.5	99.2	99.5
Middle	96.8	97.2	97.5
Ring	97.0	97.3	98.3
Little	98.2	98.5	99.2
Left			
Index	98.8	99.1	99.2
Middle	97.4	97.7	97.8
Ring	98.1	98.6	98.9
Little	98.3	98.4	98.6

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
Index			
Either	99.5	99.5	99.6
Both	93.6	94.4	94.8
Middle			
Either	99.4	99.5	99.6
Both	90.8	91.3	91.7
Ring			
Either	99.5	99.6	99.7
Both	91.8	92.5	93.6
Little			
Either	99.5	99.5	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
Right			
Any	99.7	99.8	99.9
At Least Two	99.4	99.4	99.8
At Least Three	98.5	98.7	99.3
All Four	92.8	94.3	95.5
Left			
Any	99.8	99.8	99.8
At Least Two	99.4	99.4	99.6
At Least Three	98.7	98.8	99.0
All Four	94.6	95.8	96.0

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
Right			
Either Index or Middle	99.5	99.6	99.8
Both Index and Middle	95.8	96.7	97.2
Left			
Either Index or Middle	99.5	99.5	99.6
Both Index and Middle	96.7	97.3	97.3

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
Right			
Any	99.7	99.7	99.9
At Least Two	98.9	99.0	99.5
All Three	93.8	95.0	95.9
Left			
Any	99.7	99.7	99.8
At Least Two	99.0	99.1	99.3
All Three	95.5	96.6	96.7

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+0009 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+0009 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+0009 are enumerated in Table 8.

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

Failure Reason	Fingers
Finger Not Found	132
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+0009 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+0009 at detecting fingers missing from an image.

Result	Percentage
Missed	25.0
Correctly Identified	75.0
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	0.11	0.12	0.12
Right	0.05	0.05	0.05
Combined	0.08	0.08	0.08

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	**99.9**	0.1
Right	0.1	**99.9**

3 Identification Flats ("ThreeInch" Data)

3.1 Segmentation Timing

All algorithms are run over a small fixed corpus of ThreeInch 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. Times are measured by running a single process on an isolated compute node equipped with an Intel Gold 6254 CPU (submissions received prior to February 2022 were timed with a Intel Xeon E5-4650 CPU).

Box plots of segmentation times are separated by hand in Figure 6, with tabular representations are enumerated in Table 12. Results are reported in milliseconds

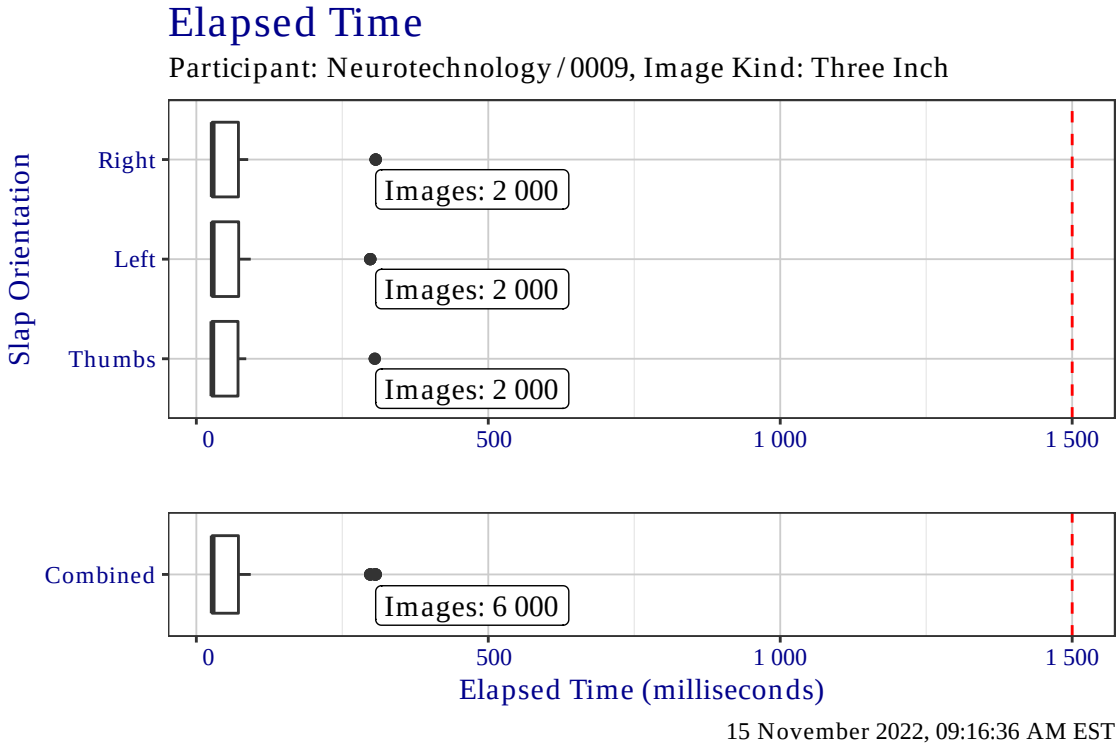

Figure 6: Box plots of elapsed time in milliseconds when segmenting the ThreeInch timing test corpus, separated by slap orientation.

Table 12: Elapsed time in milliseconds when segmenting the ThreeInch timing test corpus, separated by slap orientation.

	Right	Left	Thumbs	Combined
Minimum	25	26	25	25
25%	27	27	27	27
Median	28	28	27	28
75%	72	73	71	72
Maximum	307	298	306	307

3.2 Segmentation Centers and Dimensions

3.2.1 Segmentation Centers

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

Plots of segmentation centers for the right hand ThreeInch data are shown in Figure 7, for the left hand in Figure 8, and for thumbs in Figure 9. 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.

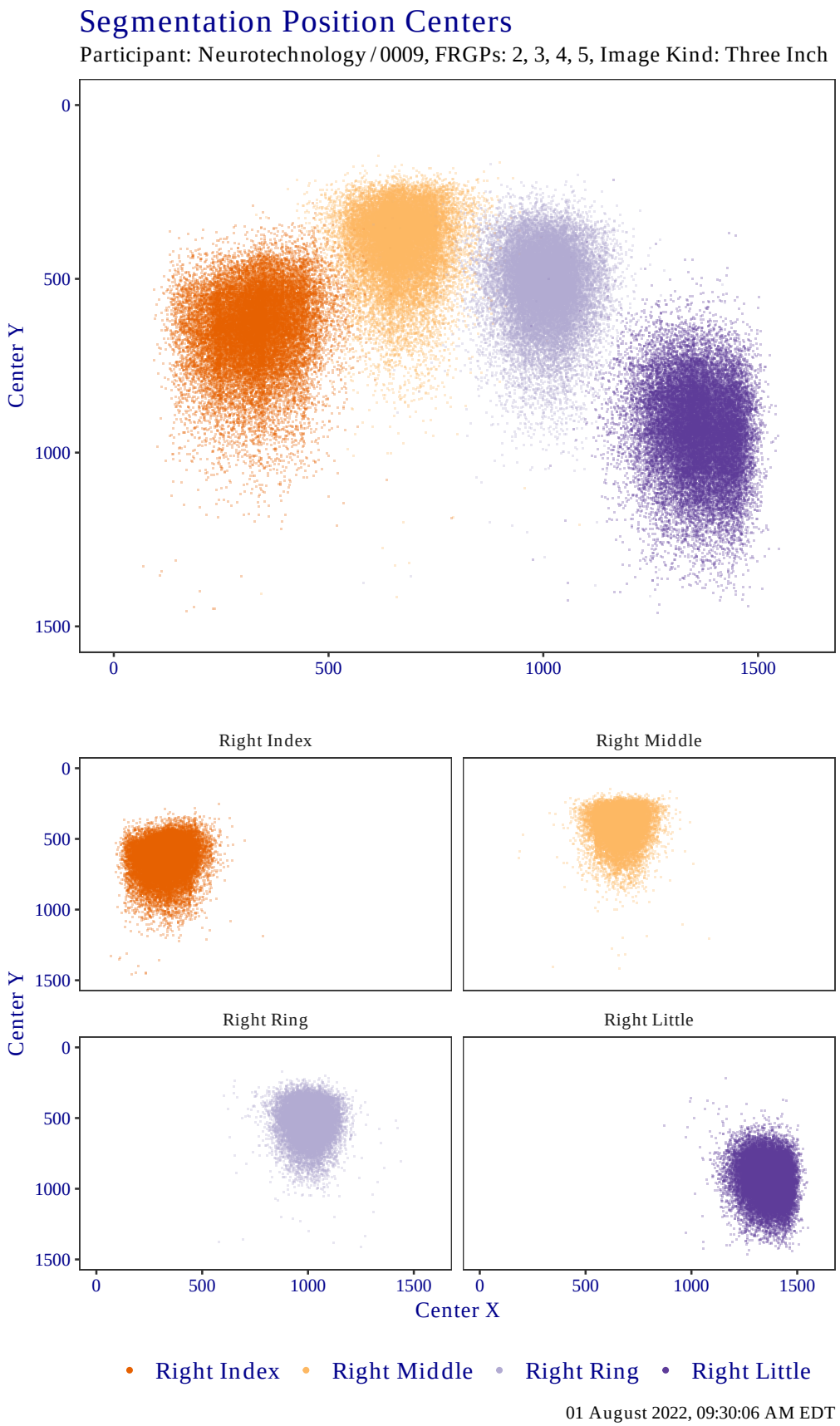

Figure 7: Segmentation centers for right hand ThreeInch data.

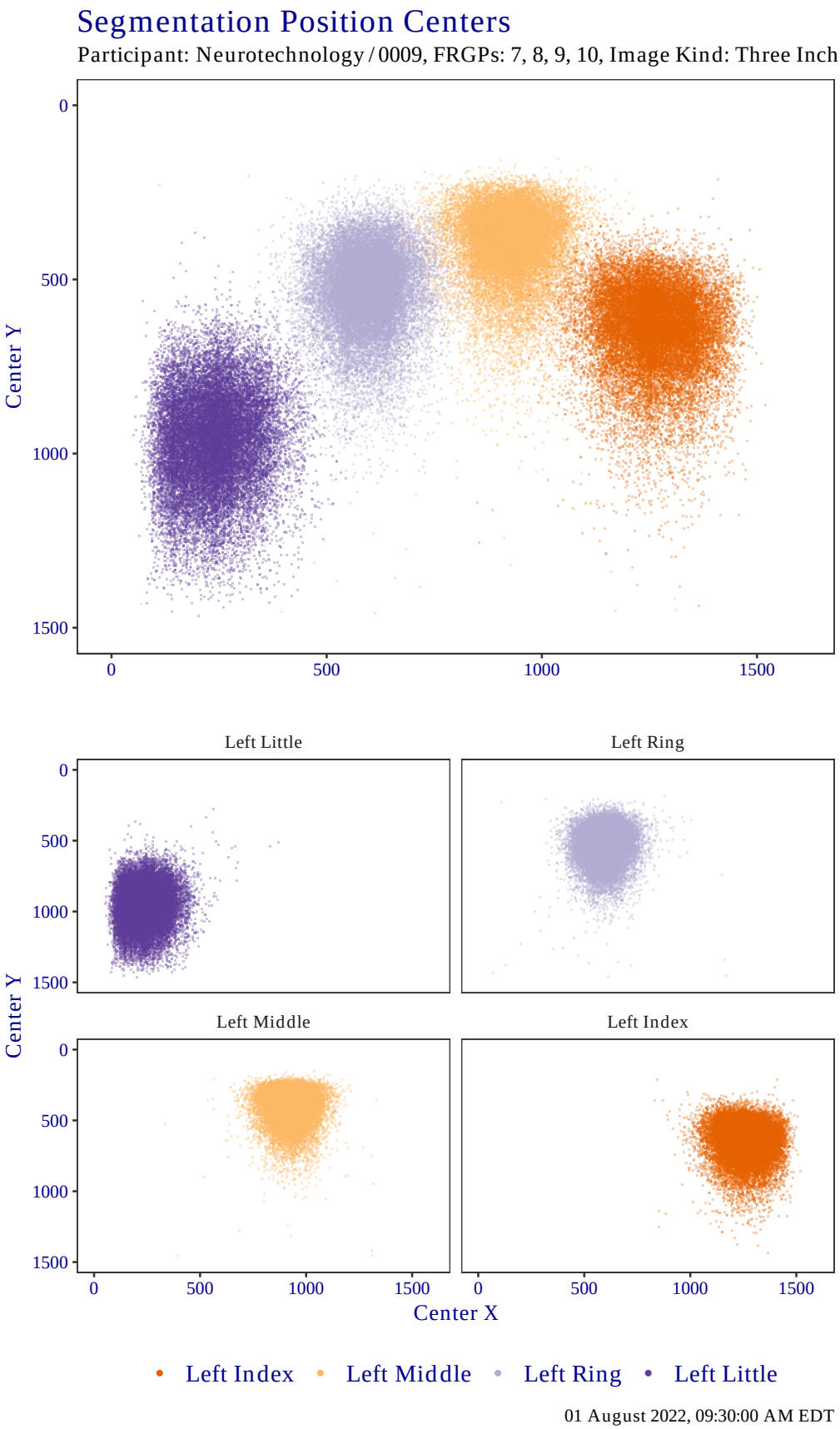

Figure 8: Segmentation centers for left hand ThreeInch data.

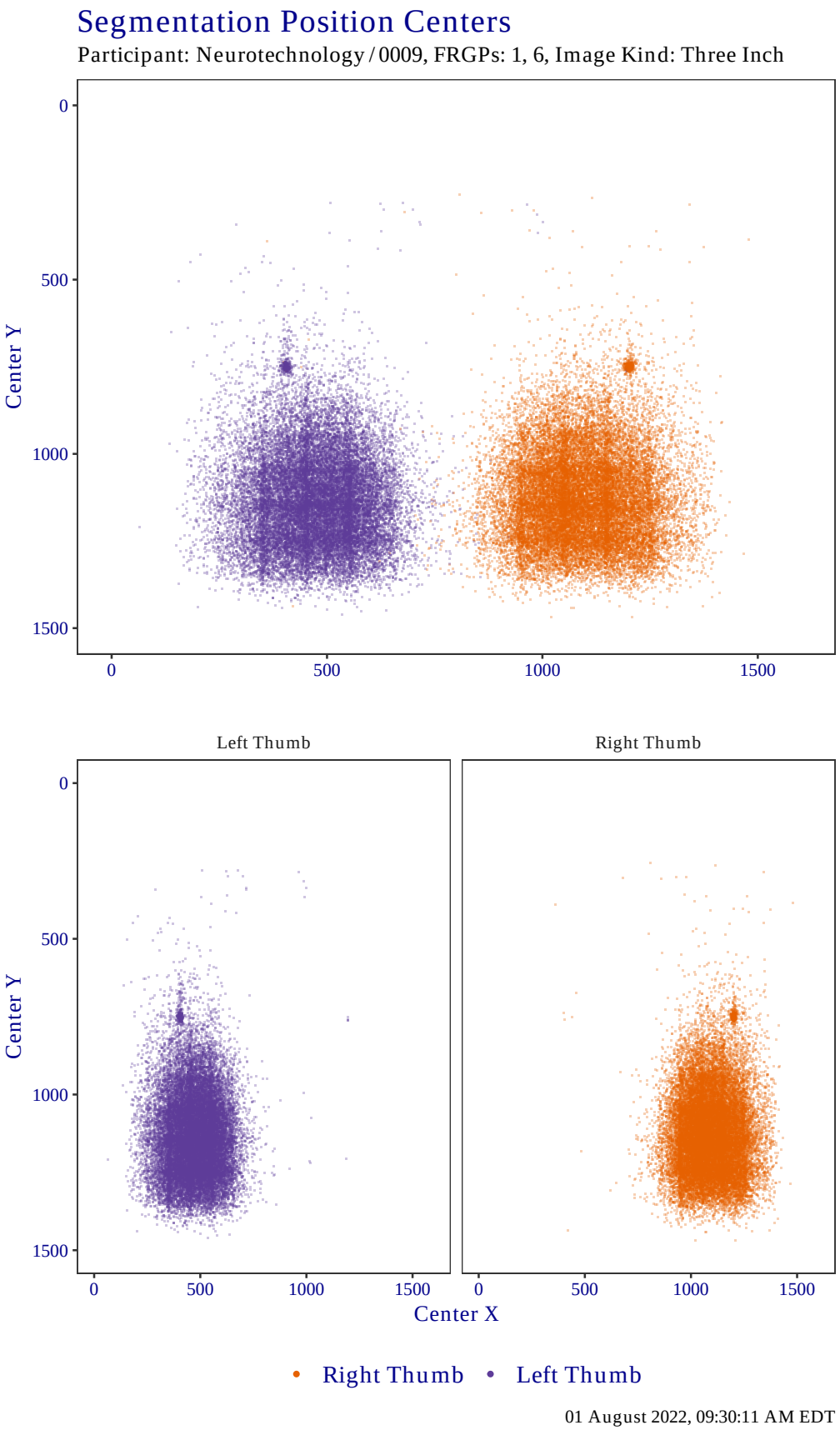

Figure 9: Segmentation centers for thumb ThreeInch data.

3.2.2 Segmentation Dimensions

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

Plots of segmentation position dimensions for the right hand ThreeInch data are shown in Figure 11, for the left hand in Figure 10, and for thumbs in Figure 12. 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.

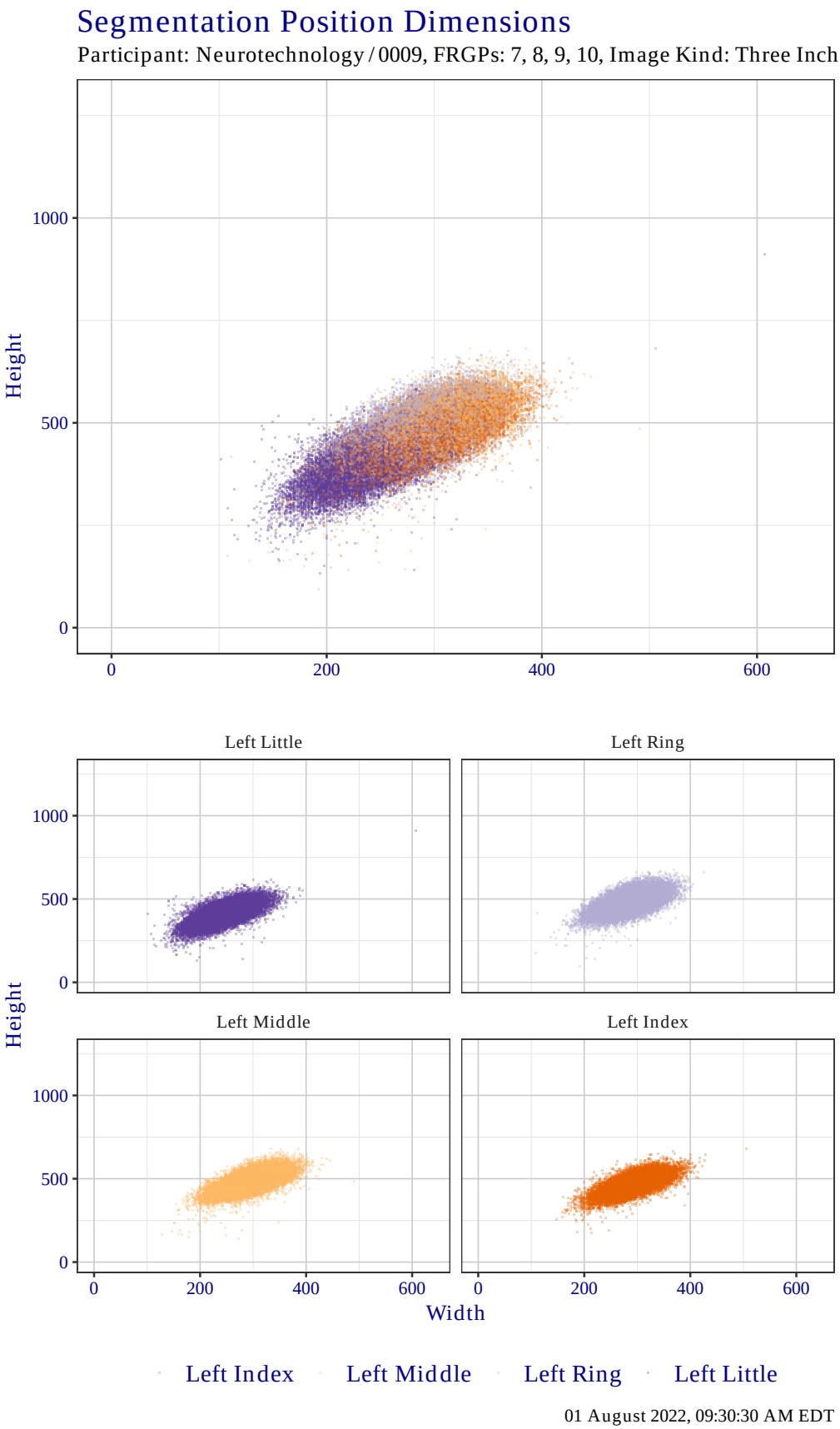

Figure 10: Segmentation position dimensions for left hand ThreeInch data.

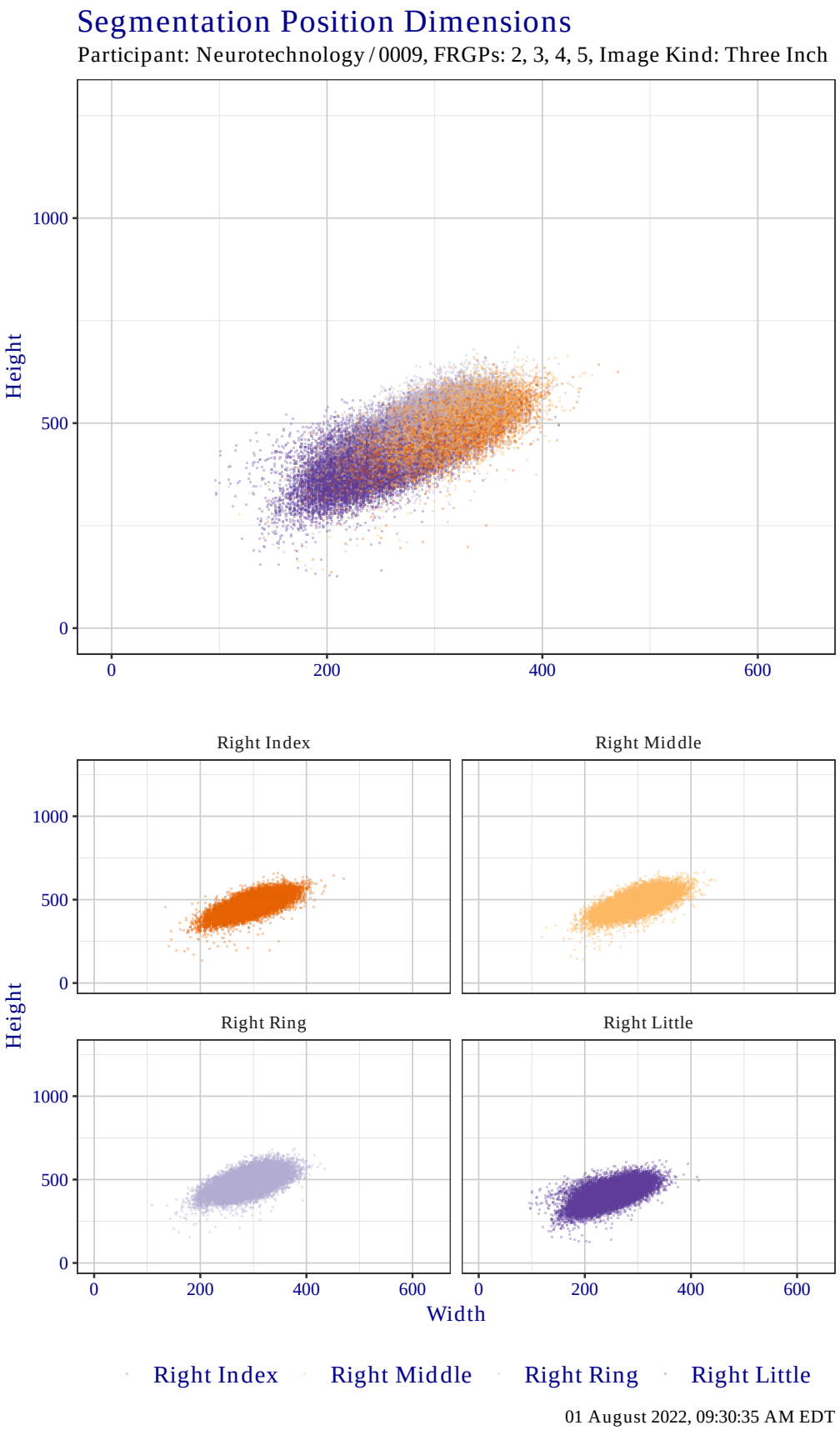

Figure 11: Segmentation position dimensions for right hand ThreeInch data.

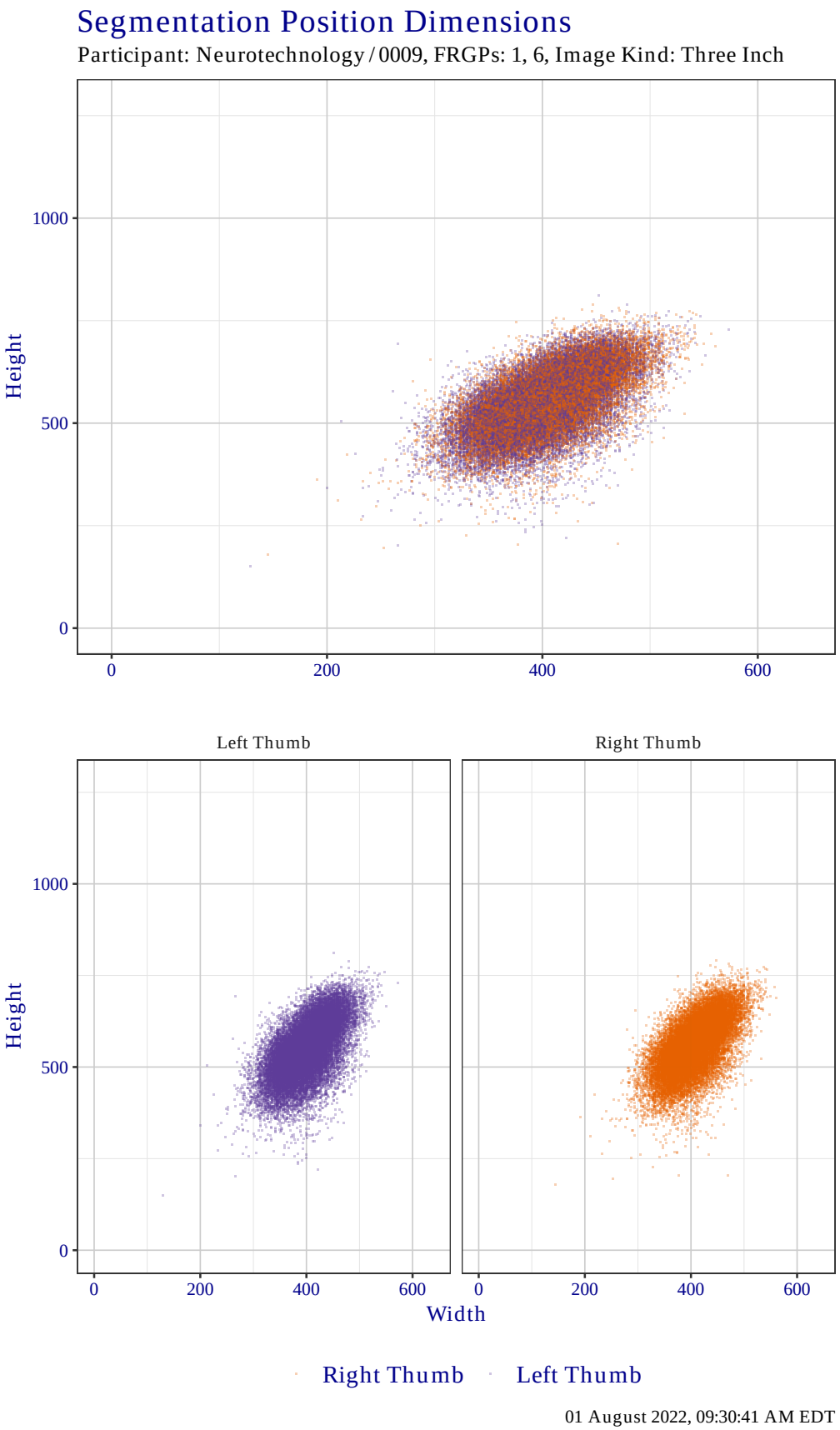

Figure 12: Segmentation position dimensions for thumb ThreeInch data.

3.3 Detailed Segmentation Statistics

This section shows detailed results of segmentation of ThreeInch 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 13 shows how successful Neurotechnology+0009 segmented fingers for each subject in the test corpus. Table 14 shows success for specific finger positions over the entire test corpus. Similarly, Table 15 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 16 shows success for combinations of all fingers, Table 17 for just the index and middle fingers, and Table 18 for all except the little finger.

Table 13: 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	99.6	99.6	99.7
3	98.5	98.5	98.5
4	98.2	98.2	98.2
5	95.9	95.9	95.9
6	95.9	95.9	95.9
7	95.8	95.8	95.8
8	95.5	95.5	95.6
9	93.5	93.7	94.0
10	82.9	83.6	84.7

Table 14: 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
Right			
Thumb	96.7	96.9	97.2
Index	99.5	99.5	99.6
Middle	99.4	99.4	99.6
Ring	98.6	98.8	99.0
Little	97.3	97.3	97.4
Left			
Thumb	95.2	95.4	95.7
Index	99.4	99.5	99.5
Middle	99.4	99.4	99.7
Ring	98.9	99.1	99.3
Little	97.6	97.7	97.7

Table 15: 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
Thumb			
Either	99.1	99.1	99.2
Both	92.9	93.3	93.8
Index			
Either	99.9	99.9	99.9
Both	96.3	96.4	96.5
Middle			
Either	99.8	99.8	99.9
Both	96.2	96.3	96.7
Ring			
Either	99.8	99.8	99.8
Both	95.0	95.4	95.8
Little			
Either	99.5	99.5	99.5
Both	92.8	92.8	92.9

Table 16: Percentage of segmentation success by hand for combinations of all ten fingers of a ThreeInch 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
Right			
Any	99.7	99.7	99.7
At Least Two	98.5	98.5	98.5
At Least Three	98.4	98.4	98.4
At Least Four	97.6	97.6	97.8
All Five	88.3	88.7	89.2
Left			
Any	99.7	99.7	99.8
At Least Two	98.5	98.5	98.5
At Least Three	98.3	98.3	98.4
At Least Four	97.6	97.6	97.8
All Five	87.3	87.8	88.4

Table 17: 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 gnored. *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
Right			
Either	99.9	99.9	99.9
Both	99.0	99.1	99.3
Left			
Either	99.9	99.9	99.9
Both	98.9	99.0	99.3

Table 18: Percentage of segmentation success by hand when only considering combinations of index, middle, and ring fingers. In *Ignoring Bottom Y*, the bottom left and right Y coordinates are ignored. *Ignoring Bottom X and Y* only checks the locations of the top left and right coordinates.

Fingers	Standard Scoring	Ignoring Bottom Y	Ignoring Bottom X and Y
Right			
Any	99.9	99.9	99.9
At Least Two	99.8	99.8	99.8
All Three	97.8	98.1	98.4
Left			
Any	99.9	99.9	99.9
At Least Two	99.7	99.8	99.8
All Three	98.0	98.3	98.8

3.4 Handling Troublesome Images

3.4.1 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+0009 did **not** report any capture failures.

3.4.1.1 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+0009 did not attempt any recovery segmentations.

3.4.2 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+0009 are enumerated in Table 19.

Table 19: Count of self-reported segmentation failure reasoning.

Failure Reason	Fingers
Finger Not Found	253
Finger Found, but Can't Segment	0
Vendor Defined	0

3.4.3 Identifying Missing Fingers

A small portion of the test corpus in SlapSeg III are missing fingers. Table 20 shows how successful Neurotechnology+0009 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 20: Performance of Neurotechnology+0009 at detecting fingers missing from an image.

Result	Percentage
Missed	41.6
Correctly Identified	58.4
Other Failure: Finger Found, but Can't Segment	0.0
Other Failure: Vendor Defined	0.0
Other Failure: Segmentation Not Attempted	0.0

3.4.4 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 21 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 21: 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	0.14	0.14	0.14
Right	0.16	0.16	0.16
Thumbs	0.07	0.07	0.07
Combined	0.12	0.12	0.12

3.5 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., Identification Flat) and needed to determine whether the image was of the left hand, right hand, or thumbs.

Overall Three Inch accuracy: 99.8%

Table 22: Percentage of accuracy when determining hand orientation of a three 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	Thumbs
Left	**99.8**	0.2	0
Right	0.3	**99.7**	0
Thumbs	0.1	0.1	**99.8**

4 Upper Palm ("FiveInch" Data)

4.1 Segmentation Timing

All algorithms are run over a small fixed corpus of FiveInch 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. Times are measured by running a single process on an isolated compute node equipped with an Intel Gold 6254 CPU (submissions received prior to February 2022 were timed with a Intel Xeon E5-4650 CPU).

Box plots of segmentation times are separated by slap orientation in Figure 13. Tabular representations are enumerated in Table 23. Results are reported in milliseconds.

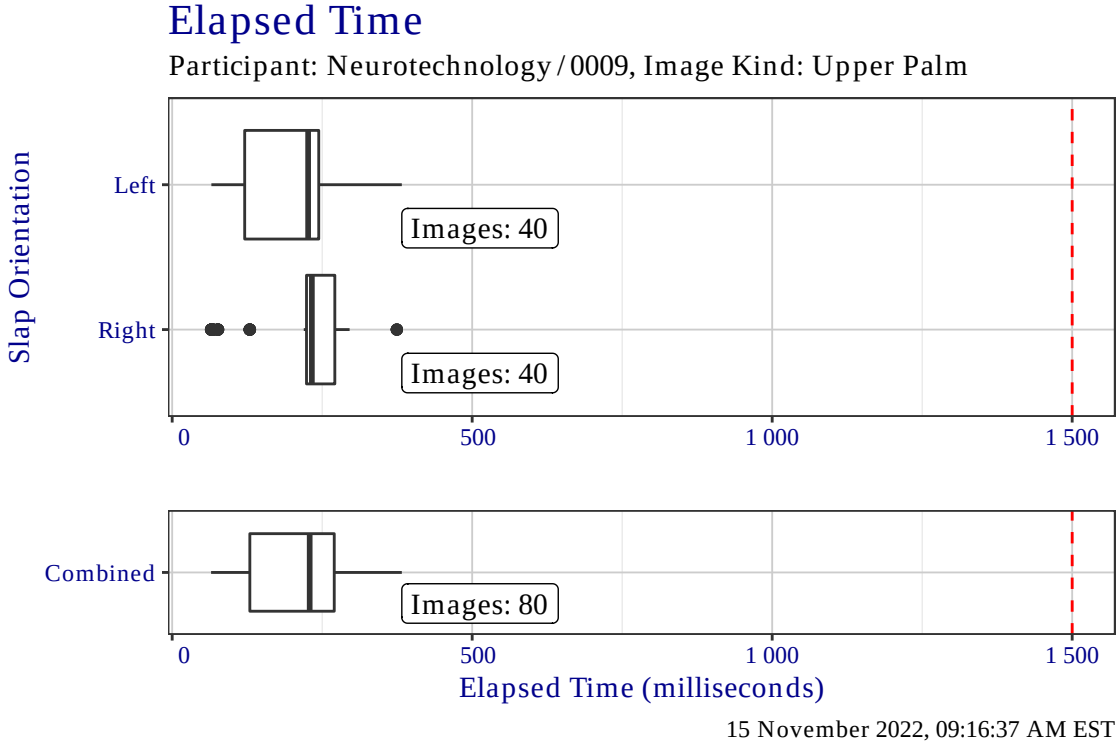

Figure 13: Box plots of elapsed time in milliseconds when segmenting the FiveInch timing test corpus, separated by slap orientation.

Table 23: Elapsed time in milliseconds when segmenting the FiveInch timing test corpus, separated by slap orientation.

	Right	Left	Combined
Minimum	65	65	65
25%	224	121	129
Median	233	227	229
75%	271	244	270
Maximum	374	383	383

4.2 Segmentation Centers and Dimensions

4.2.1 Segmentation Centers

The plots in this section show the distribution of segmentation position centers (x, y) for FiveInch 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 FiveInch data are shown in Figure 14 and plots of segmentation centers for the left hand are shown in Figure 15. 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.

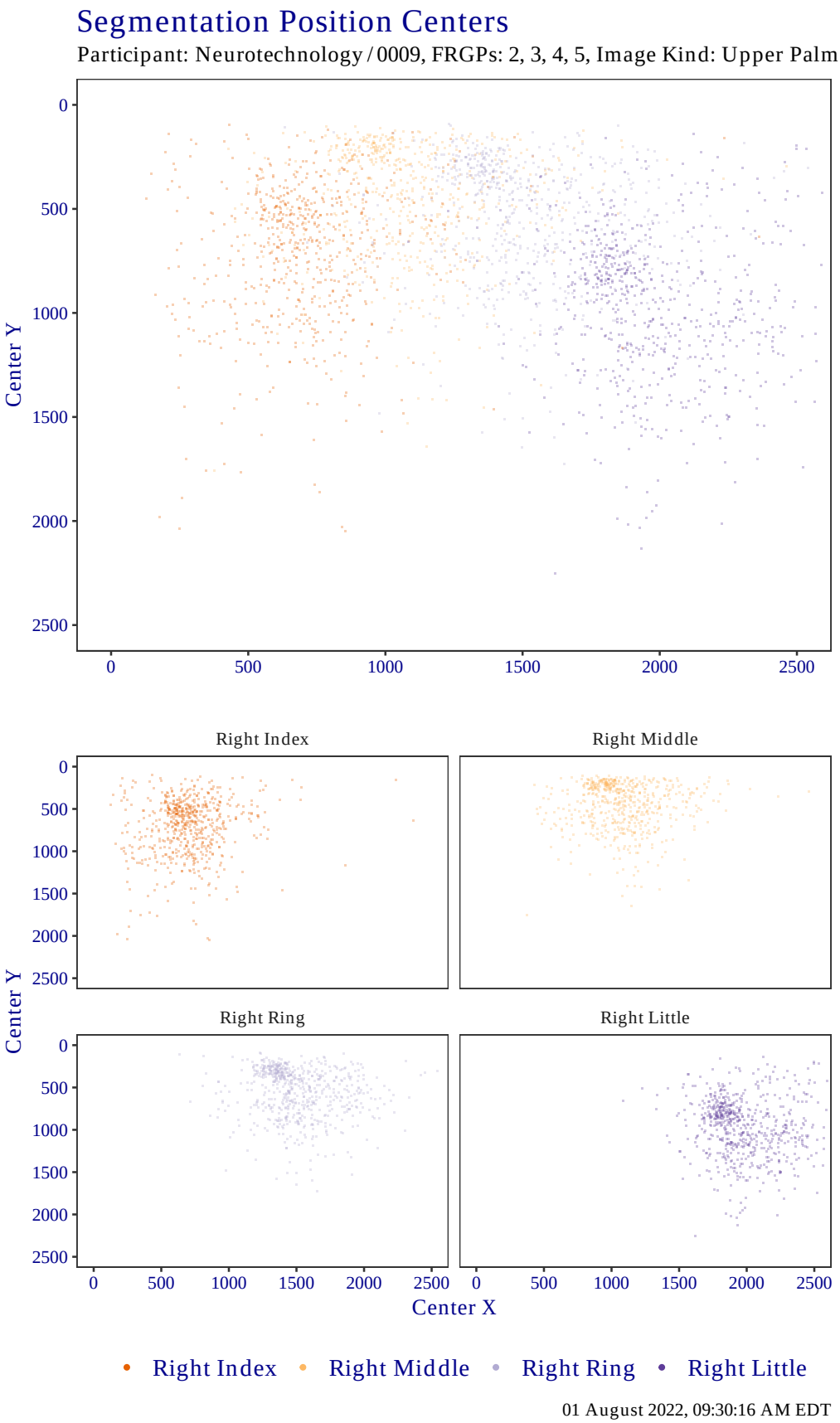

Figure 14: Segmentation centers for right hand FiveInch data.

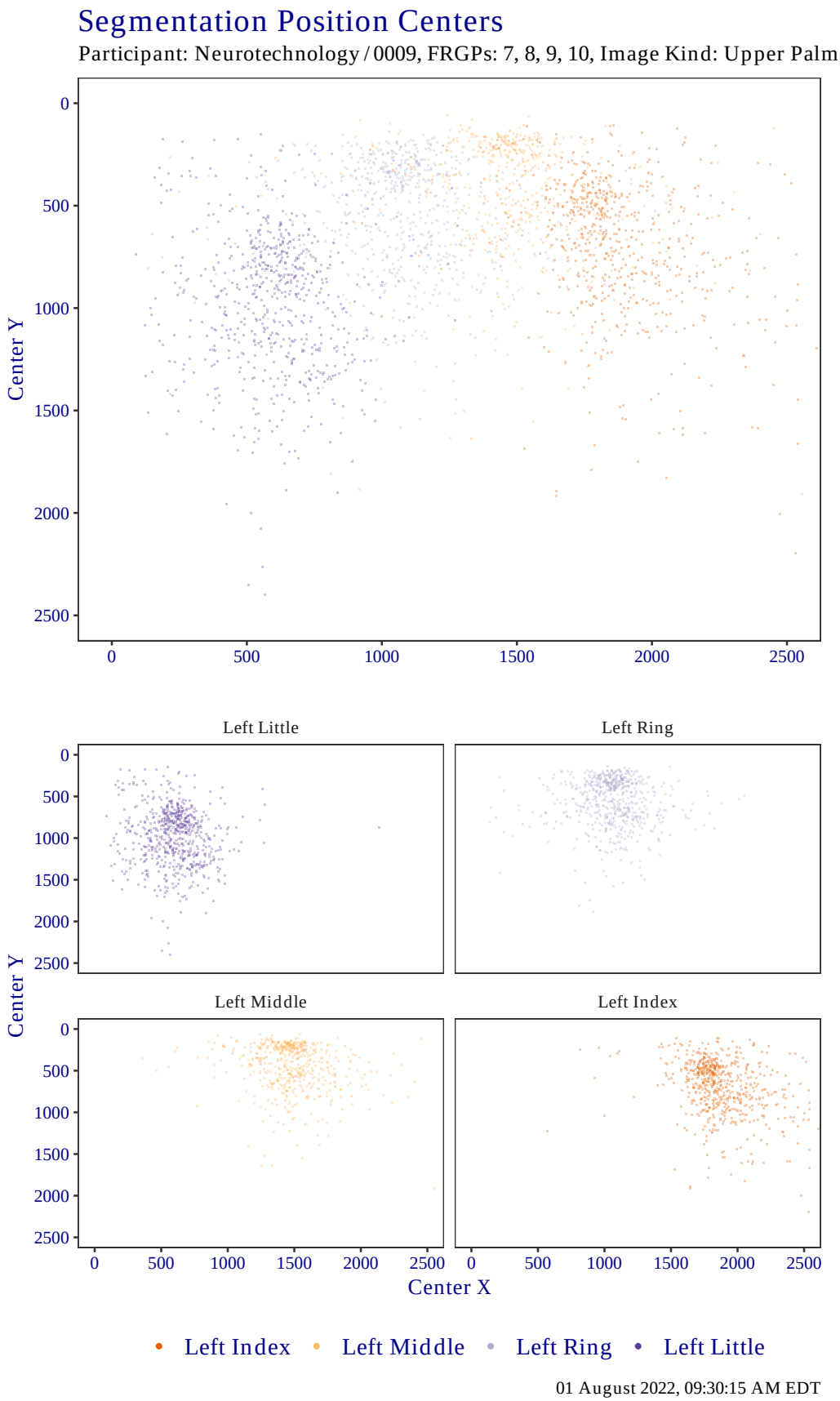

Figure 15: Segmentation centers for left hand FiveInch data.

4.2.2 Segmentation Dimensions

The plots in this section show the distribution of segmentation position widths and heights for FiveInch 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 FiveInch data are shown in Figure 16 and the left hand in Figure 17. 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.

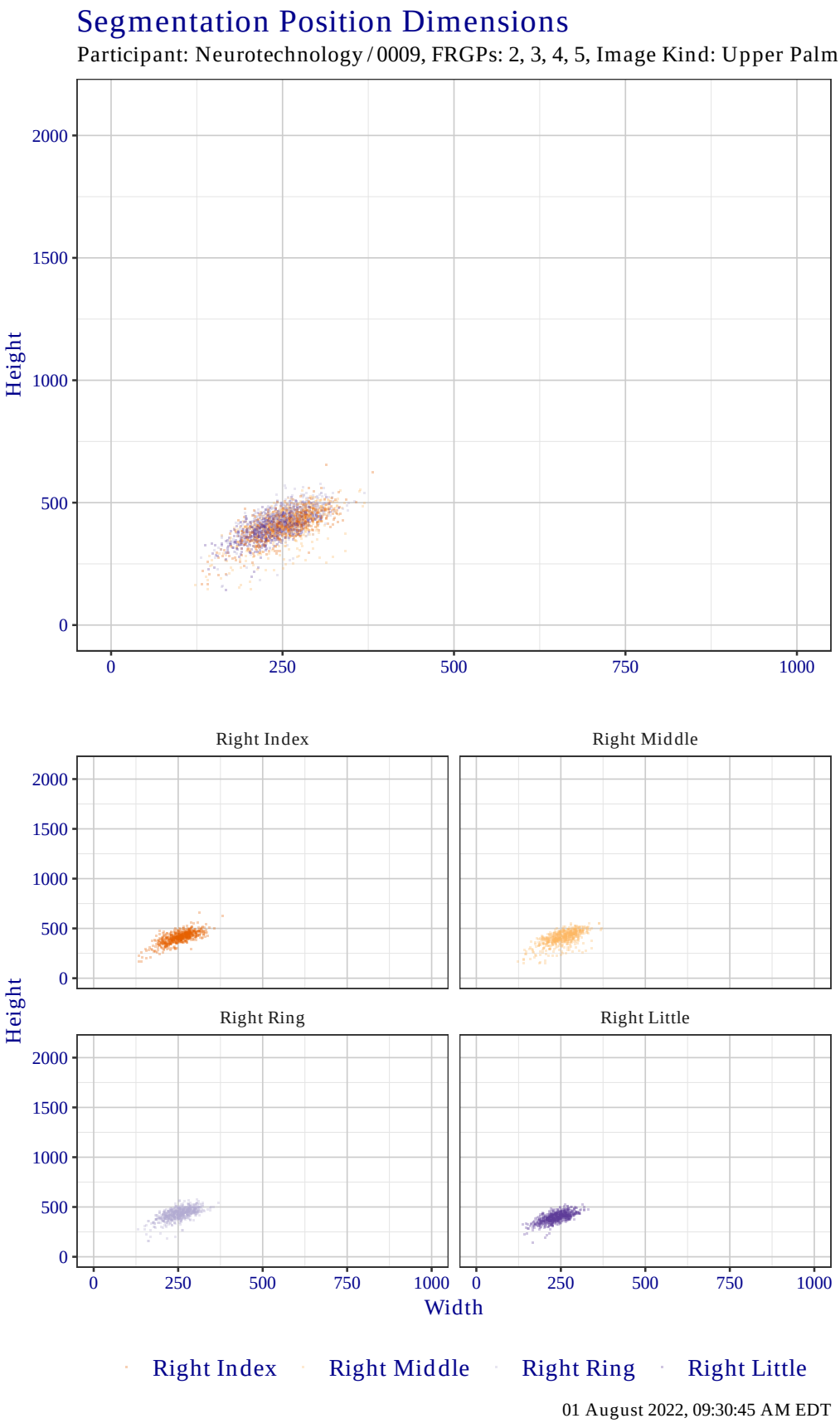

Figure 16: Segmentation position dimensions for right hand FiveInch data.

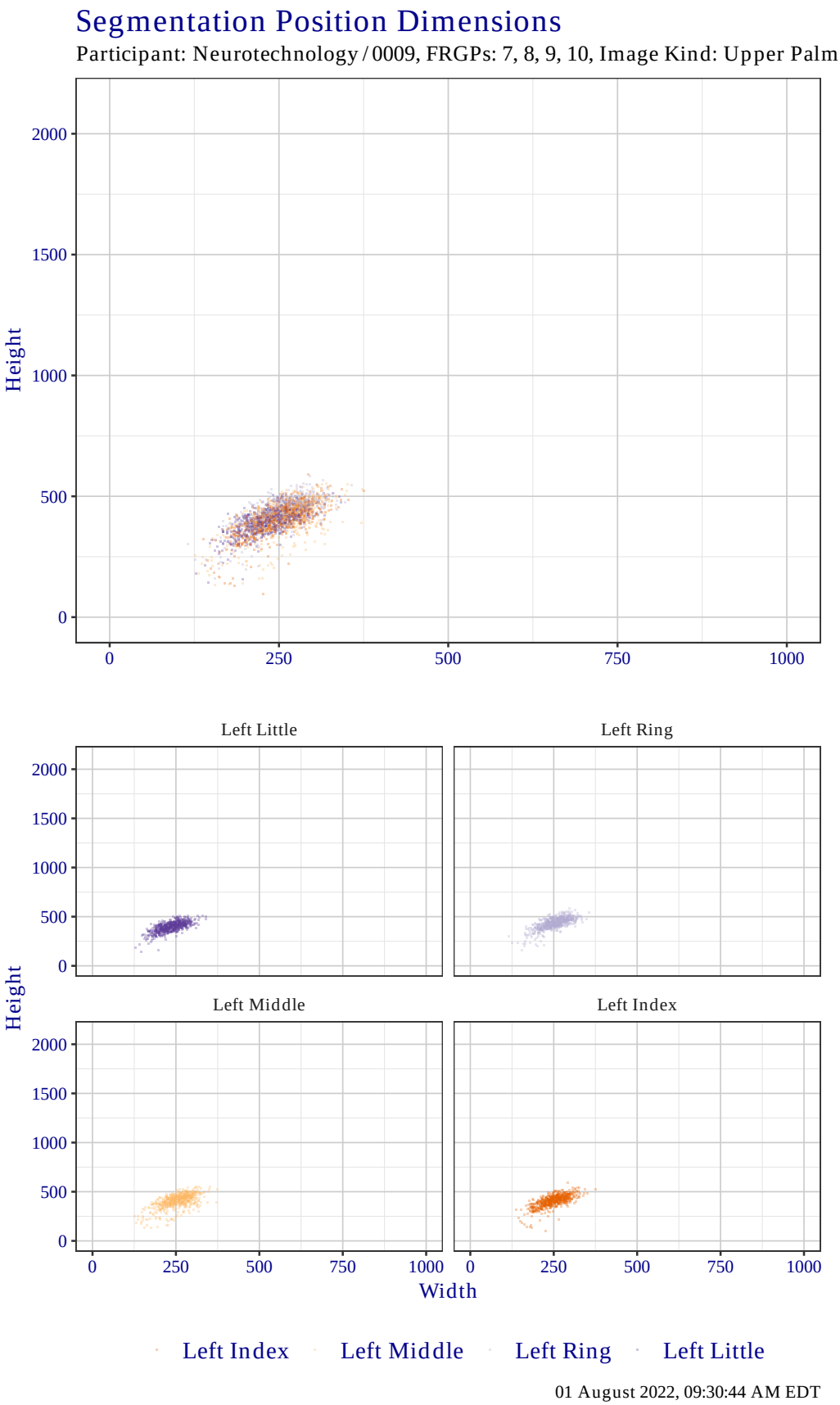

Figure 17: Segmentation position dimensions for left hand FiveInch data.

4.3 Detailed Segmentation Statistics

This section shows detailed results of segmentation of FiveInch 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 24 shows how successful Neurotechnology+0009 segmented fingers for each subject in the test corpus. Table 25 shows success for specific finger positions over the entire test corpus. Similarly, Table 26 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 27 shows success for combinations of all fingers, Table 28 for just the index and middle fingers, and Table 29 for all except the little finger.

Table 24: 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	99.7	99.7	99.7
2	99.1	99.1	99.3
3	98.6	98.6	98.6
4	96.6	96.7	96.7
5	91.0	91.2	91.7
6	82.9	83.1	84.3
7	72.5	72.6	73.9
8	53.9	53.9	57.3

Table 25: 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
Right			
Index	88.4	88.4	88.8
Middle	88.2	88.2	89.4
Ring	88.7	88.8	89.5
Little	85.5	85.5	88.0
Left			
Index	87.8	87.8	88.2
Middle	87.3	87.4	87.7
Ring	90.5	90.8	91.1
Little	83.4	83.4	84.5

Table 26: 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
Index			
Either	95.8	95.8	95.8
Both	79.1	79.1	79.8
Middle			
Either	96.6	96.6	96.7
Both	77.5	77.6	78.9
Ring			
Either	97.2	97.5	97.8
Both	80.5	80.8	81.4
Little			
Either	95.7	95.7	96.3
Both	71.9	71.9	74.8

Table 27: Percentage of segmentation success by hand for combinations of all eight fingers of a FiveInch 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
Right			
Any	98.8	98.8	98.8
At Least Two	94.8	94.8	95.2
At Least Three	87.0	87.0	87.9
All Four	70.2	70.3	73.8
Left			
Any	98.8	98.9	98.9
At Least Two	94.0	94.3	94.7
At Least Three	87.4	87.4	87.9
All Four	68.7	68.8	69.9

Table 28: 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
Right			
Either Index or Middle	94.7	94.7	94.9
Both Index and Middle	81.9	81.9	83.2
Left			
Either Index or Middle	94.8	95.0	95.1
Both Index and Middle	80.2	80.2	80.8

Table 29: 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
Right			
Any	97.5	97.5	97.6
At Least Two	91.2	91.2	91.8
All Three	76.6	76.7	78.3
Left			
Any	97.2	97.5	97.5
At Least Two	90.8	91.0	91.4
All Three	77.5	77.6	78.1

4.4 Handling Troublesome Images

4.4.1 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+0009 did **not** report any capture failures.

4.4.1.1 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+0009 did not attempt any recovery segmentations.

4.4.2 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+0009 are enumerated in Table 30.

Table 30: Count of self-reported segmentation failure reasoning.

Failure Reason	Fingers
Finger Not Found	1 143
Finger Found, but Can't Segment	0
Vendor Defined	0

4.4.3 Identifying Missing Fingers

A small portion of the test corpus in SlapSeg III are missing fingers. Table 31 shows how successful Neurotechnology+0009 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 31: Performance of Neurotechnology+0009 at detecting fingers missing from an image.

Result	Percentage
Missed	12.2
Correctly Identified	87.8
Other Failure: Finger Found, but Can't Segment	0.0
Other Failure: Vendor Defined	0.0
Other Failure: Segmentation Not Attempted	0.0

4.4.4 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 32 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 32: 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	6.90	7.03	7.03
Right	8.24	8.24	8.51
Combined	7.57	7.64	7.77

4.5 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., upper palm) and needed to determine whether the image was of the left or right hand.

Overall Upper Palm accuracy: 88.0%

Table 33: Percentage of accuracy when determining hand orientation of an upper palm 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	**80.7**	19.3
Right	4.6	**95.4**

5 Full Palm ("EightInch" Data)

5.1 Segmentation Timing

All algorithms are run over a small fixed corpus of EightInch 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. Times are measured by running a single process on an isolated compute node equipped with an Intel Gold 6254 CPU (submissions received prior to February 2022 were timed with a Intel Xeon E5-4650 CPU).

Box plots of segmentation times are separated by slap orientation in Figure 18. Tabular representations are enumerated in Table 34. Results are reported in milliseconds.

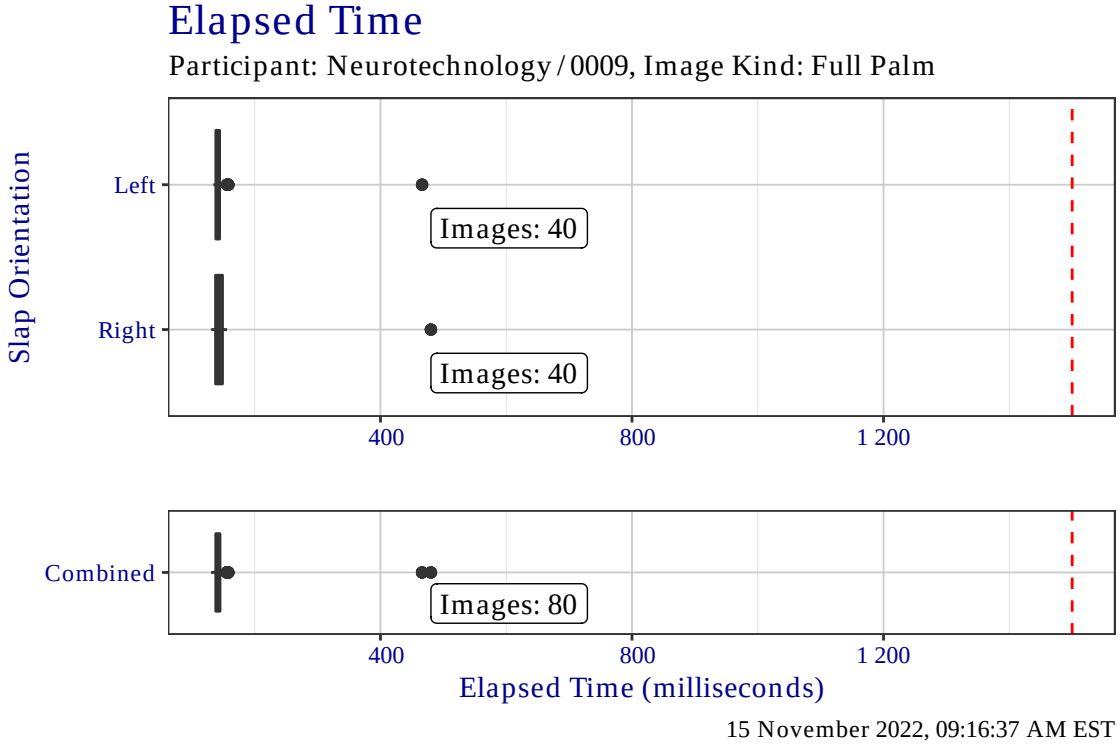

Figure 18: Box plots of elapsed time in milliseconds when segmenting the EightInch timing test corpus, separated by slap orientation.

Table 34: Elapsed time in milliseconds when segmenting the EightInch timing test corpus, separated by slap orientation and capture technology.

	Right	Left	Combined
Minimum	131	134	131
25%	138	138	138
Median	143	141	142
75%	149	144	145
Maximum	480	466	480

5.2 Segmentation Centers and Dimensions

5.2.1 Segmentation Centers

The plots in this section show the distribution of segmentation position centers (x, y) for EightInch 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 EightInch data are shown in Figure 19 and plots of segmentation centers for the left hand are shown in Figure 20. 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.

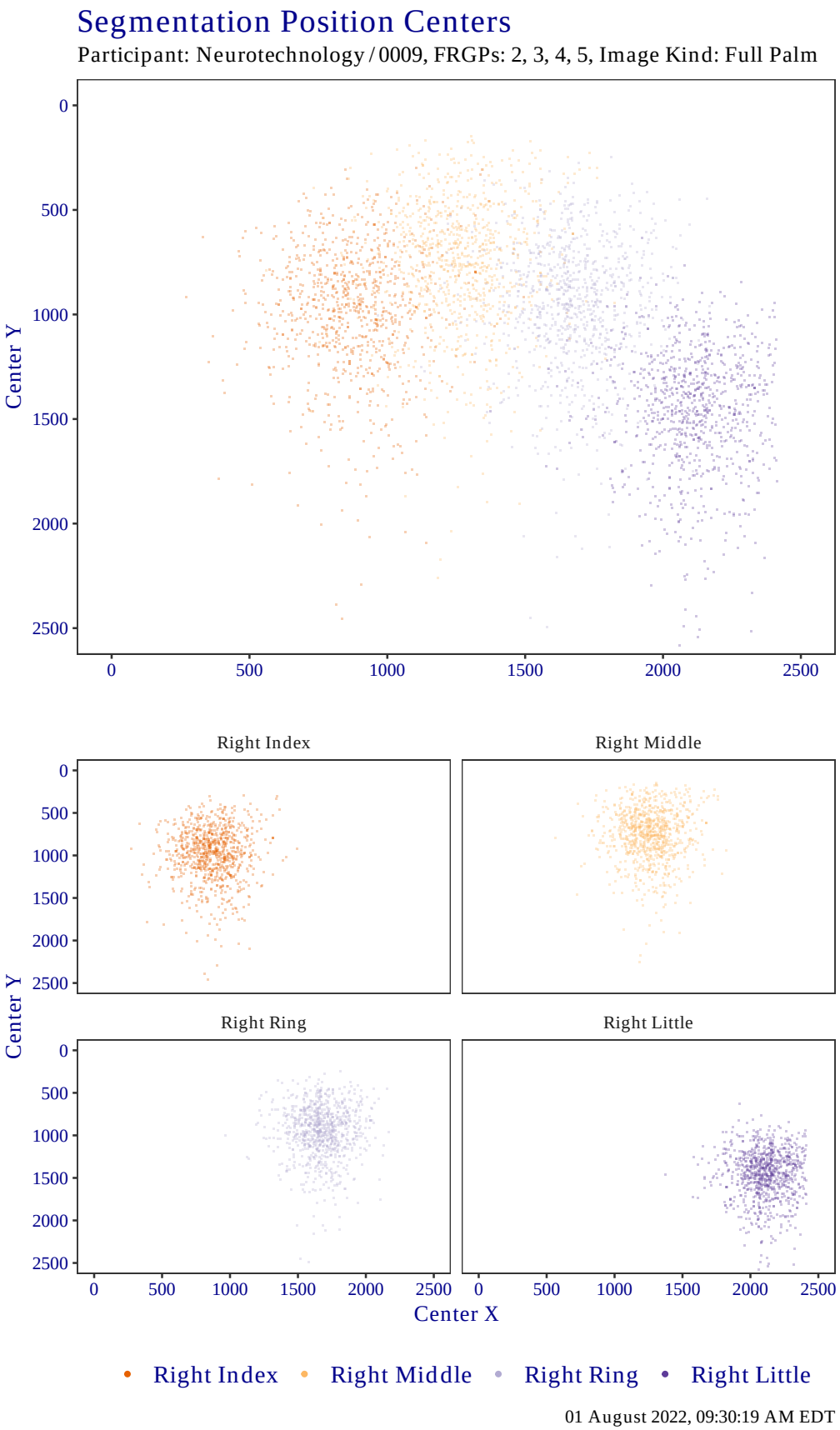

Figure 19: Segmentation centers for right hand EightInch data.

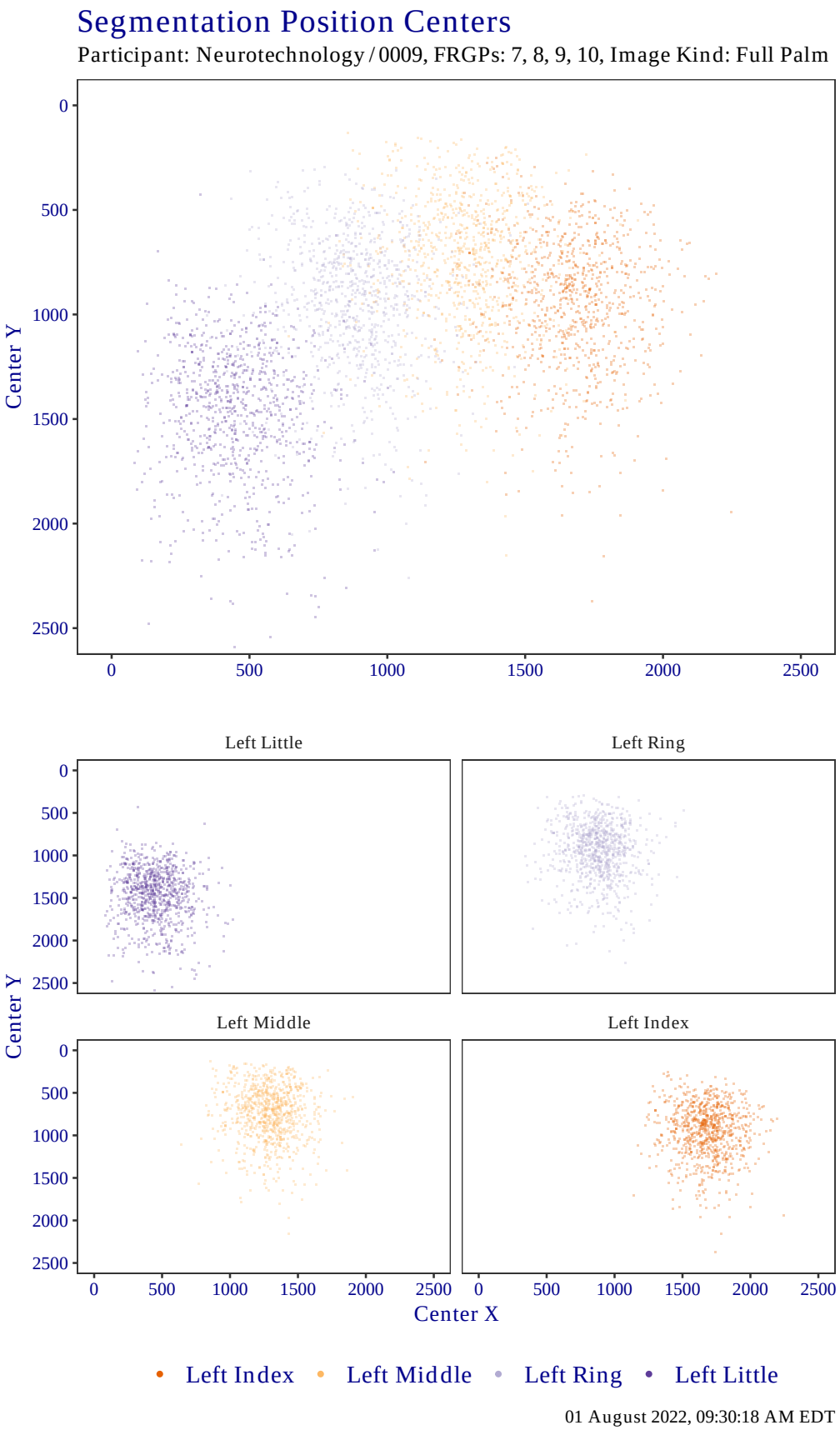

Figure 20: Segmentation centers for left hand EightInch data.

5.2.2 Segmentation Dimensions

The plots in this section show the distribution of segmentation position widths and heights for EightInch 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 EightInch data are shown in Figure 21 and the left hand in Figure 22. 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.

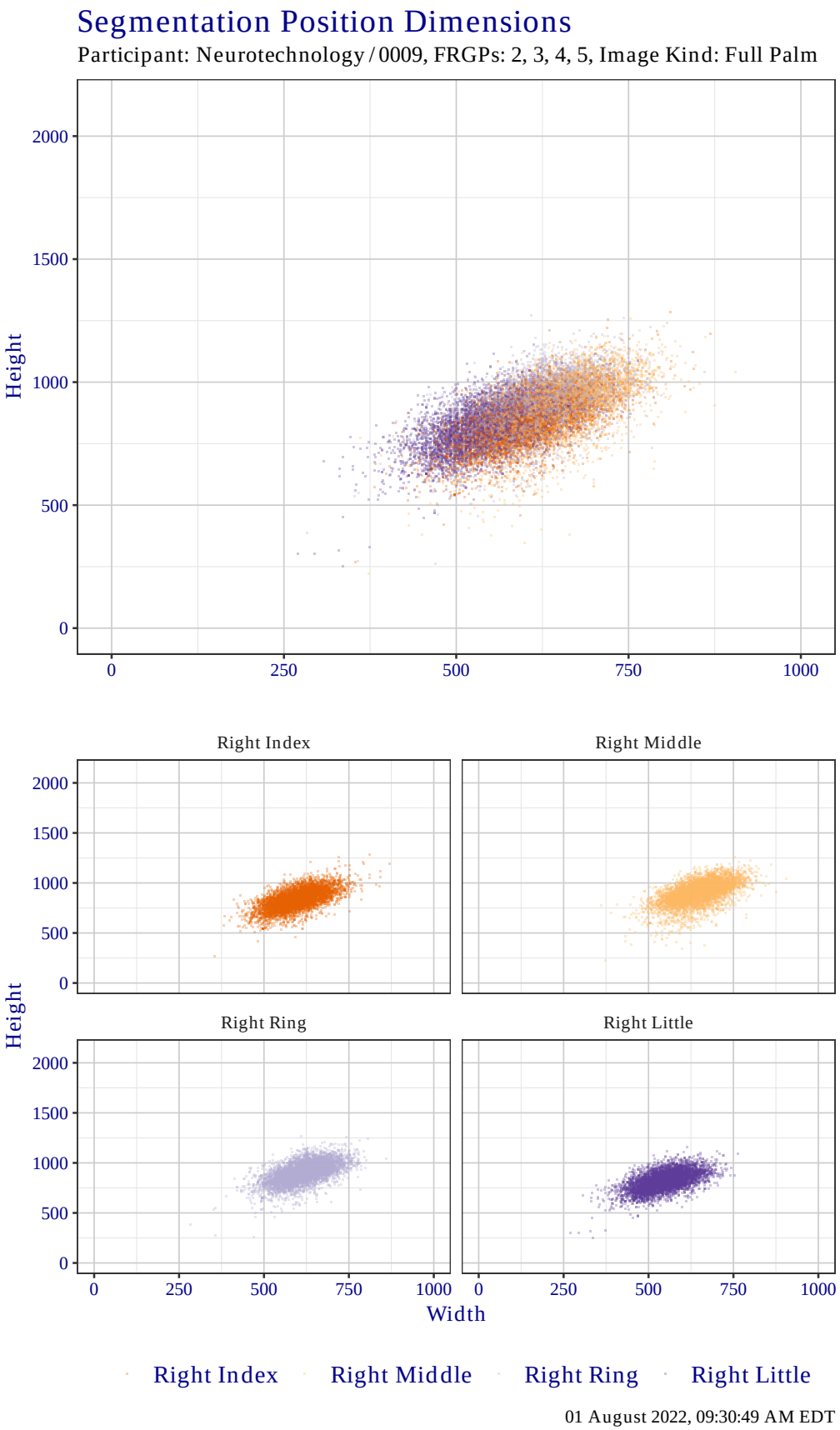

Figure 21: Segmentation position dimensions for right hand EightInch data.

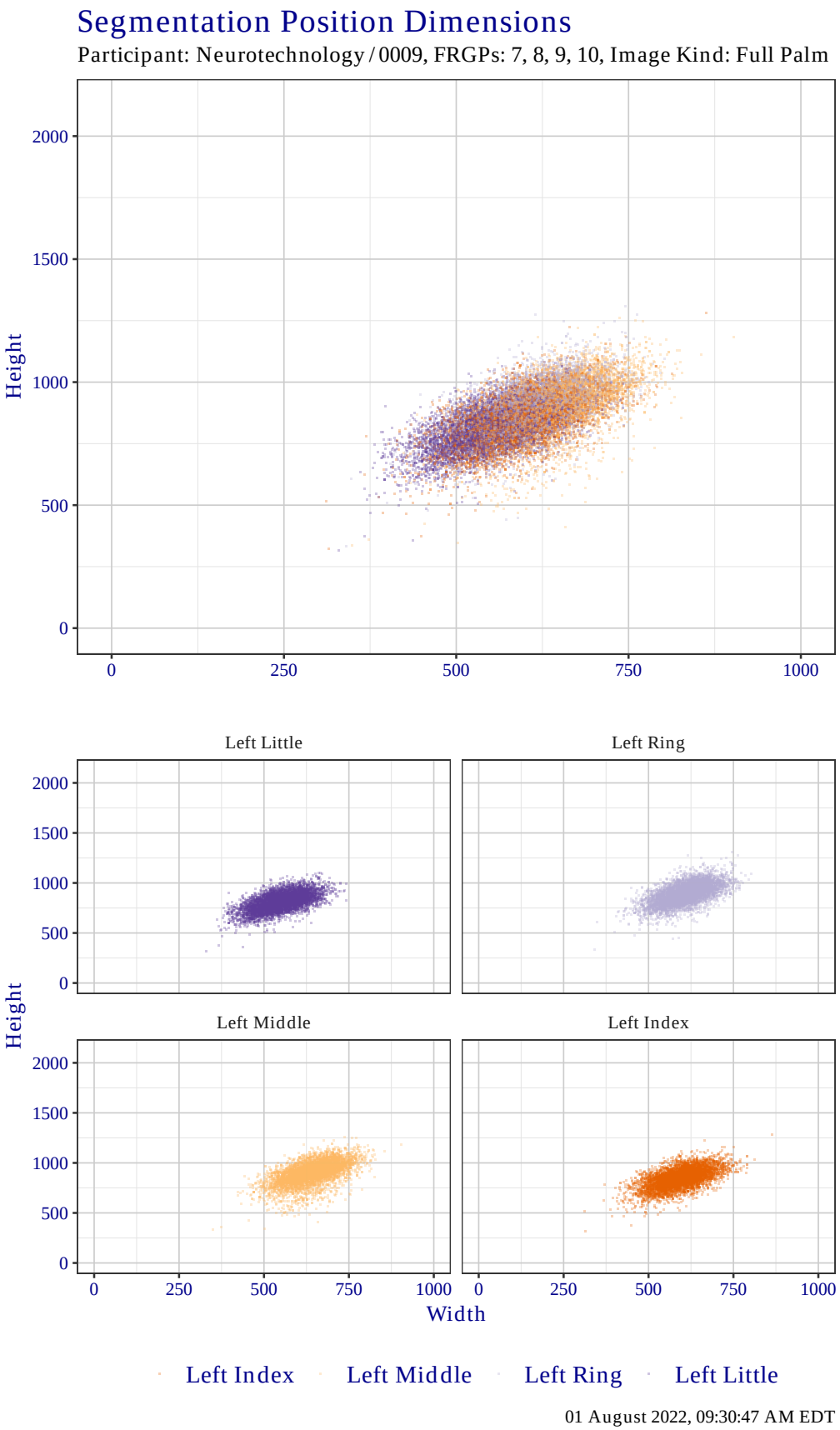

Figure 22: Segmentation position dimensions for left hand EightInch data.

5.3 Detailed Segmentation Statistics

NOTE: *The following segmentation statistics are based on a limited subset (approximately 15%) of the anticipated Full Palm dataset. This analysis will be updated as soon as NIST can obtain the remainder of the dataset.*

This section shows detailed results of segmentation of EightInch 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 35 shows how successful Neurotechnology+0009 segmented fingers for each subject in the test corpus. Table 36 shows success for specific finger positions over the entire test corpus. Similarly, Table 37 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 38 shows success for combinations of all fingers, Table 39 for just the index and middle fingers, and Table 40 for all except the little finger.

Table 35: 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	100.0	100.0	100.0
2	100.0	100.0	100.0
3	100.0	100.0	100.0
4	99.8	99.8	99.9
5	98.9	98.9	99.0
6	98.4	98.4	98.4
7	97.2	97.5	97.6
8	89.5	89.7	90.8

Table 36: 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
Right			
Index	97.6	97.7	97.7
Middle	97.7	97.7	98.0
Ring	98.4	98.5	98.7
Little	98.2	98.2	98.6
Left			
Index	98.6	98.6	98.7
Middle	97.9	97.9	97.9
Ring	97.9	97.9	98.3
Little	97.5	97.6	97.6

Table 37: 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
Index			
Either	100.0	100.0	100.0
Both	96.2	96.3	96.4
Middle			
Either	99.7	99.7	99.7
Both	96.0	96.0	96.3
Ring			
Either	99.5	99.7	99.8
Both	96.8	96.8	97.2
Little			
Either	100.0	100.0	100.0
Both	95.6	95.7	96.2

Table 38: Percentage of segmentation success by hand for combinations of all eight fingers of a EightInch 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
Right			
Any	99.4	99.4	99.5
At Least Two	99.2	99.2	99.2
At Least Three	98.9	98.9	99.0
All Four	94.4	94.6	95.4
Left			
Any	99.7	99.7	99.7
At Least Two	99.4	99.4	99.4
At Least Three	98.7	98.7	98.7
All Four	94.1	94.3	94.7

Table 39: 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
Right			
Either Index or Middle	99.2	99.2	99.2
Both Index and Middle	96.1	96.2	96.6
Left			
Either Index or Middle	99.5	99.5	99.5
Both Index and Middle	97.0	97.0	97.1

Table 40: 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
Right			
Any	99.4	99.4	99.4
At Least Two	99.0	99.0	99.0
All Three	95.3	95.5	96.1
Left			
Any	99.5	99.5	99.5
At Least Two	98.9	98.9	98.9
All Three	96.1	96.1	96.6

5.4 Handling Troublesome Images

5.4.1 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+0009 did **not** report any capture failures.

5.4.1.1 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+0009 did not attempt any recovery segmentations.

5.4.2 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+0009 are enumerated in Table 41.

Table 41: Count of self-reported segmentation failure reasoning.

Failure Reason	Fingers
Finger Not Found	274
Finger Found, but Can't Segment	0
Vendor Defined	0

5.4.3 Identifying Missing Fingers

A small portion of the test corpus in SlapSeg III are missing fingers. Table 42 shows how successful Neurotechnology+0009 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 42: Performance of Neurotechnology+0009 at detecting fingers missing from an image.

Result	Percentage
Missed	0.0
Correctly Identified	100.0
Other Failure: Finger Found, but Can't Segment	0.0
Other Failure: Vendor Defined	0.0
Other Failure: Segmentation Not Attempted	0.0

5.4.4 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 43 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 43: 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	0.57	0.57	0.57
Right	0.34	0.34	0.34
Combined	0.46	0.46	0.46

5.5 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., full palm) and needed to determine whether the image was of the left or right hand.

Overall Full Palm accuracy: 99.2%

Table 44: Percentage of accuracy when determining hand orientation of an full palm 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	**99.3**	0.7
Right	0.9	**99.1**

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 45, results are shown of how successful Neurotechnology+0009 segmented fingers for each subject in the test corpus. Table 46 shows success for specific finger positions over the entire test corpus. Similarly, Table 47 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 48 shows success for combinations of all fingers, Table 50 for the all except the little finger, and Table 49 for just the index and middle fingers.

Table 45: 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 [99.9, 100.0]
2	99.8 [99.7, 99.9]	99.8 [99.7, 99.9]	99.8 [99.8, 99.9]
3	99.5 [99.4, 99.6]	99.5 [99.4, 99.7]	99.6 [99.5, 99.7]
4	98.9 [98.8, 99.1]	99.0 [98.9, 99.2]	99.2 [99.0, 99.3]
5	95.4 [95.0, 95.7]	95.4 [95.0, 95.8]	95.7 [95.3, 96.0]
6	94.7 [94.4, 95.1]	94.8 [94.4, 95.2]	95.3 [94.9, 95.6]
7	93.1 [92.7, 93.5]	93.5 [93.1, 93.9]	94.3 [93.9, 94.7]
8	85.2 [84.6, 85.8]	87.4 [86.8, 88.0]	88.6 [88.0, 89.1]

Table 46: 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
Right			
Index	98.5 [98.3, 98.7]	99.2 [99.1, 99.3]	99.5 [99.4, 99.6]
Middle	96.8 [96.6, 97.1]	97.2 [97.0, 97.4]	97.5 [97.3, 97.7]
Ring	97.0 [96.8, 97.2]	97.3 [97.1, 97.5]	98.3 [98.1, 98.5]
Little	98.2 [98.0, 98.4]	98.5 [98.3, 98.6]	99.2 [99.1, 99.3]
Left			
Index	98.8 [98.6, 98.9]	99.1 [98.9, 99.2]	99.2 [99.0, 99.3]
Middle	97.4 [97.2, 97.6]	97.7 [97.5, 97.9]	97.8 [97.6, 98.0]
Ring	98.1 [97.9, 98.3]	98.6 [98.4, 98.8]	98.9 [98.7, 99.0]
Little	98.3 [98.1, 98.4]	98.4 [98.2, 98.6]	98.6 [98.4, 98.7]

Table 47: 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
Index			
Either	99.5 [99.4, 99.6]	99.5 [99.4, 99.7]	99.6 [99.5, 99.7]
Both	93.6 [93.1, 93.9]	94.4 [94.0, 94.8]	94.8 [94.4, 95.2]
Middle			
Either	99.4 [99.3, 99.6]	99.5 [99.4, 99.6]	99.6 [99.5, 99.7]
Both	90.8 [90.3, 91.3]	91.3 [90.9, 91.8]	91.7 [91.2, 92.2]
Ring			
Either	99.5 [99.4, 99.6]	99.6 [99.4, 99.7]	99.7 [99.6, 99.8]
Both	91.8 [91.3, 92.2]	92.5 [92.0, 92.9]	93.6 [93.1, 94.0]
Little			
Either	99.5 [99.3, 99.6]	99.5 [99.3, 99.6]	99.5 [99.4, 99.6]
Both	92.6 [92.2, 93.1]	93.1 [92.6, 93.5]	93.9 [93.5, 94.4]

Table 48: 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
Right			
Any	99.7 [99.7, 99.8]	99.8 [99.7, 99.8]	99.9 [99.8, 99.9]
At Least Two	99.4 [99.3, 99.5]	99.4 [99.4, 99.5]	99.8 [99.6, 99.7]
At Least Three	98.5 [98.5, 98.7]	98.7 [98.6, 98.8]	99.3 [99.1, 99.2]
All Four	92.8 [93.4, 93.9]	94.3 [94.8, 95.2]	95.5 [95.5, 95.9]
Left			
Any	99.8 [99.7, 99.8]	99.8 [99.7, 99.8]	99.8 [99.8, 99.9]
At Least Two	99.4 [99.3, 99.5]	99.4 [99.4, 99.5]	99.6 [99.6, 99.7]
At Least Three	98.7 [98.5, 98.7]	98.8 [98.6, 98.8]	99.0 [99.1, 99.2]
All Four	94.6 [93.4, 93.9]	95.8 [94.8, 95.2]	96.0 [95.5, 95.9]

Table 49: 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
Right			
Either Index or Middle	99.5 [99.4, 99.6]	99.6 [99.5, 99.6]	99.8 [99.6, 99.7]
Both Index and Middle	95.8 [96.0, 96.4]	96.7 [96.8, 97.2]	97.2 [97.1, 97.4]
Left			
Either Index or Middle	99.5 [99.4, 99.6]	99.5 [99.5, 99.6]	99.6 [99.6, 99.7]
Both Index and Middle	96.7 [96.0, 96.4]	97.3 [96.8, 97.2]	97.3 [97.1, 97.4]

Table 50: 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
Right			
Any	99.7 [99.6, 99.7]	99.7 [99.7, 99.8]	99.9 [99.8, 99.9]
At Least Two	98.9 [98.8, 99.0]	99.0 [99.0, 99.1]	99.5 [99.3, 99.5]
All Three	93.8 [94.4, 94.8]	95.0 [95.5, 95.9]	95.9 [96.1, 96.5]
Left			
Any	99.7 [99.6, 99.7]	99.7 [99.7, 99.8]	99.8 [99.8, 99.9]
At Least Two	99.0 [98.8, 99.0]	99.1 [99.0, 99.1]	99.3 [99.3, 99.5]
All Three	95.5 [94.4, 94.8]	96.6 [95.5, 95.9]	96.7 [96.1, 96.5]

A.2 Jaccard Index

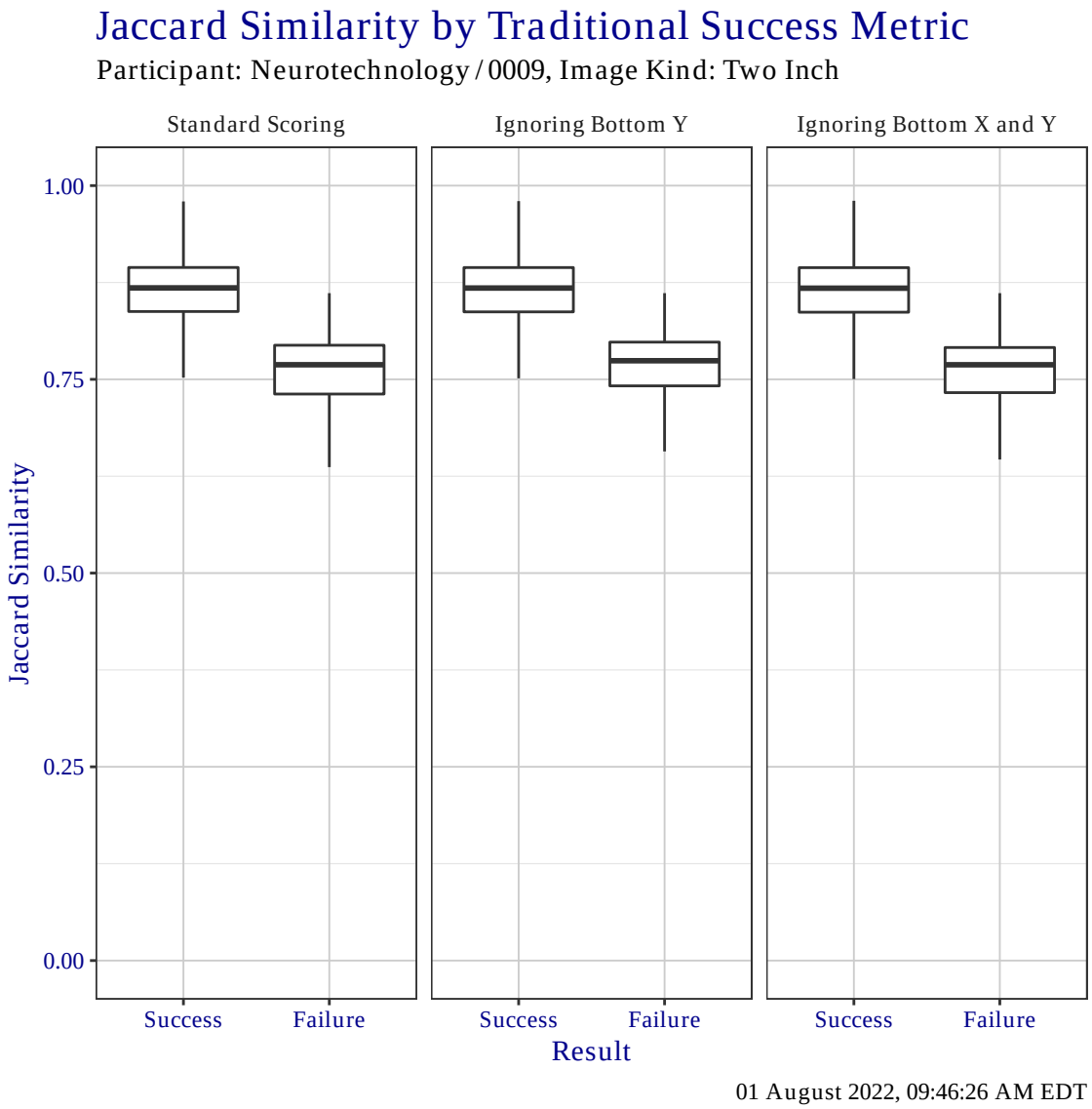

Figure 23: Boxplot of Jaccard similarity indices as compared to the traditional success metrics. Outliers have been removed for clarity.

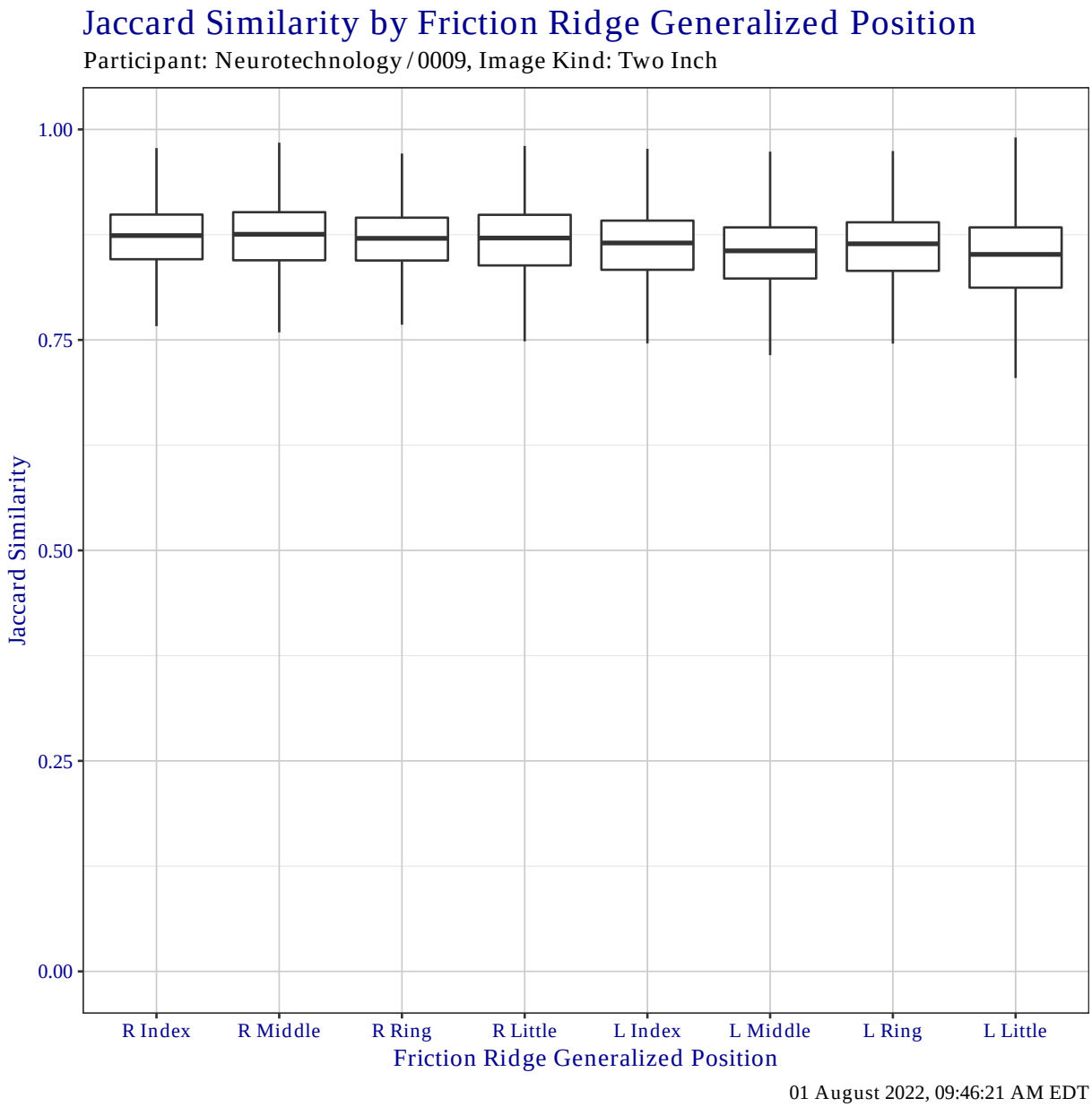

Figure 24: Boxplot of Jaccard similarity indices for each friction ridge generalized position. Outliers have been removed for clarity.

Table 51: 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	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
1	100.0	100.0	99.9	99.9	69.3	6.7	0.1
2	99.9	99.9	99.9	99.7	45.0	0.9	0.0
3	99.8	99.8	99.8	99.1	25.6	0.1	0.0
4	99.6	99.5	99.3	97.1	11.8	0.0	0.0
5	95.9	95.9	95.9	92.6	4.3	0	0
6	95.8	95.8	95.8	86.9	1.3	0	0
7	95.8	95.7	95.0	74.4	0.3	0	0
8	95.3	94.8	89.7	48.6	0.0	0	0

Table 52: 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
Right						
Index	0.1	0.0	0.3	6.1	69.5	24.0
Middle	0.1	0.0	0.2	6.3	67.0	26.4
Ring	0.1	0.0	0.3	6.0	72.9	20.7
Little	0.1	0.1	0.8	8.6	66.6	23.8
Left						
Index	0.2	0.0	0.4	9.6	71.4	18.4
Middle	0.2	0.1	0.7	13.2	72.5	13.3
Ring	0.1	0.2	1.0	10.4	72.0	16.3
Little	0.2	0.2	1.5	17.3	66.3	14.5

Table 53: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of all eight fingers of a TwoInch slap.

Fingers	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
Right							
Any	100.0	100.0	100.0	99.6	51.2	4.5	0.1
At Least Two	100.0	100.0	100.0	98.9	28.2	0.6	0.0
At Least Three	99.9	99.9	99.9	95.4	12.3	0.1	0.0
All Four	99.7	99.6	98.0	77.0	3.3	0.0	0.0
Left							
Any	100.0	100.0	100.0	98.7	39.9	1.9	0.1
At Least Two	99.9	99.9	99.9	95.1	16.6	0.1	0.0
At Least Three	99.8	99.8	99.5	86.9	5.2	0.0	0.0
All Four	99.5	99.1	95.8	64.1	0.8	0.0	0.0

Table 54: 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	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
Right							
Either Index or Middle	99.9	99.9	99.9	98.9	39.0	2.8	0.0
Both Index and Middle	99.8	99.8	99.3	88.0	11.5	0.2	0.0
Left							
Either Index or Middle	99.9	99.9	99.8	96.1	26.7	1.1	0.0
Both Index and Middle	99.7	99.6	98.6	79.6	5.0	0.0	0.0

Table 55: 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	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
Right							
Any	100.0	100.0	100.0	99.4	45.0	3.4	0.1
At Least Two	99.9	99.9	99.9	97.4	20.5	0.3	0.0
All Three	99.8	99.7	99.0	83.8	5.7	0.0	0.0
Left							
Any	100.0	100.0	99.9	97.8	34.4	1.5	0.1
At Least Two	99.9	99.9	99.6	91.7	11.4	0.0	0.0
All Three	99.6	99.4	97.6	74.5	2.2	0.0	0.0

B Identification Flats ("ThreeInch" Data)

B.1 Bootstrap Confidence for Segmentation Statistics

This section shows the same detailed results of segmentation of ThreeInch data from Section 3.3, 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 56, results are shown of how successful Neurotechnology+0009 segmented fingers for each subject in the test corpus. Table 57 shows success for specific finger positions over the entire test corpus. Similarly, Table 58 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 59 shows success for combinations of all fingers, Table 61 for the all except the little finger, and Table 60 for just the index and middle fingers.

Table 56: 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, 99.9]
2	99.6 [99.6, 99.7]	99.6 [99.5, 99.7]	99.7 [99.6, 99.7]
3	98.5 [98.3, 98.6]	98.5 [98.3, 98.7]	98.5 [98.4, 98.6]
4	98.2 [98.0, 98.4]	98.2 [98.0, 98.4]	98.2 [98.1, 98.4]
5	95.9 [95.7, 96.2]	95.9 [95.7, 96.2]	95.9 [95.7, 96.2]
6	95.9 [95.7, 96.1]	95.9 [95.6, 96.1]	95.9 [95.6, 96.2]
7	95.8 [95.5, 96.0]	95.8 [95.5, 96.0]	95.8 [95.6, 96.0]
8	95.5 [95.2, 95.7]	95.5 [95.2, 95.8]	95.6 [95.3, 95.8]
9	93.5 [93.2, 93.8]	93.7 [93.4, 94.0]	94.0 [93.7, 94.3]
10	82.9 [82.4, 83.3]	83.6 [83.1, 84.1]	84.7 [84.2, 85.1]

Table 57: 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
Right			
Thumb	96.7 [96.5, 97.0]	96.9 [96.7, 97.1]	97.2 [97.0, 97.4]
Index	99.5 [99.4, 99.6]	99.5 [99.4, 99.6]	99.6 [99.5, 99.7]
Middle	99.4 [99.3, 99.5]	99.4 [99.3, 99.5]	99.6 [99.5, 99.7]
Ring	98.6 [98.5, 98.8]	98.8 [98.7, 98.9]	99.0 [98.9, 99.1]
Little	97.3 [97.1, 97.5]	97.3 [97.1, 97.5]	97.4 [97.2, 97.6]
Left			
Thumb	95.2 [94.9, 95.5]	95.4 [95.1, 95.6]	95.7 [95.4, 96.0]
Index	99.4 [99.3, 99.5]	99.5 [99.4, 99.6]	99.5 [99.5, 99.6]
Middle	99.4 [99.3, 99.5]	99.4 [99.3, 99.5]	99.7 [99.6, 99.7]
Ring	98.9 [98.8, 99.0]	99.1 [99.0, 99.3]	99.3 [99.2, 99.4]
Little	97.6 [97.5, 97.8]	97.7 [97.5, 97.8]	97.7 [97.5, 97.9]

Table 58: 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
Thumb			
Either	99.1 [98.9, 99.2]	99.1 [99.0, 99.2]	99.2 [99.1, 99.3]
Both	92.9 [92.6, 93.3]	93.3 [93.0, 93.6]	93.8 [93.5, 94.2]
Index			
Either	99.9 [99.9, 99.9]	99.9 [99.9, 99.9]	99.9 [99.9, 99.9]
Both	96.3 [96.1, 96.6]	96.4 [96.1, 96.6]	96.5 [96.3, 96.7]
Middle			
Either	99.8 [99.8, 99.9]	99.8 [99.8, 99.9]	99.9 [99.8, 99.9]
Both	96.2 [96.0, 96.5]	96.3 [96.1, 96.6]	96.7 [96.5, 96.9]
Ring			
Either	99.8 [99.7, 99.8]	99.8 [99.8, 99.9]	99.8 [99.8, 99.9]
Both	95.0 [94.8, 95.3]	95.4 [95.2, 95.7]	95.8 [95.5, 96.0]
Little			
Either	99.5 [99.4, 99.6]	99.5 [99.4, 99.6]	99.5 [99.4, 99.6]
Both	92.8 [92.5, 93.2]	92.8 [92.5, 93.2]	92.9 [92.6, 93.2]

Table 59: Percentage of segmentation success by hand for combinations of all ten fingers of a ThreeInch 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
Right			
Any	99.7 [99.7, 99.8]	99.7 [99.7, 99.8]	99.7 [99.7, 99.8]
At Least Two	98.5 [98.4, 98.6]	98.5 [98.4, 98.6]	98.5 [98.4, 98.6]
At Least Three	98.4 [98.3, 98.5]	98.4 [98.3, 98.5]	98.4 [98.3, 98.5]
At Least Four	97.6 [97.5, 97.7]	97.6 [97.5, 97.8]	97.8 [97.6, 97.9]
All Five	88.3 [87.5, 88.1]	88.7 [87.9, 88.5]	89.2 [88.5, 89.1]
Left			
Any	99.7 [99.7, 99.8]	99.7 [99.7, 99.8]	99.8 [99.7, 99.8]
At Least Two	98.5 [98.4, 98.6]	98.5 [98.4, 98.6]	98.5 [98.4, 98.6]
At Least Three	98.3 [98.3, 98.5]	98.3 [98.3, 98.5]	98.4 [98.3, 98.5]
At Least Four	97.6 [97.5, 97.7]	97.6 [97.5, 97.8]	97.8 [97.6, 97.9]
All Five	87.3 [87.5, 88.1]	87.8 [87.9, 88.5]	88.4 [88.5, 89.1]

Table 60: 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
Right			
Either Index or Middle	99.9 [99.8, 99.9]	99.9 [99.8, 99.9]	99.9 [99.9, 99.9]
Both Index and Middle	99.0 [98.9, 99.1]	99.1 [99.0, 99.1]	99.3 [99.2, 99.4]
Left			
Either Index or Middle	99.9 [99.8, 99.9]	99.9 [99.8, 99.9]	99.9 [99.9, 99.9]
Both Index and Middle	98.9 [98.9, 99.1]	99.0 [99.0, 99.1]	99.3 [99.2, 99.4]

Table 61: 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
Right			
Any	99.9 [99.9, 100.0]	99.9 [99.9, 100.0]	99.9 [99.9, 100.0]
At Least Two	99.8 [99.7, 99.8]	99.8 [99.7, 99.8]	99.8 [99.8, 99.8]
All Three	97.8 [97.8, 98.1]	98.1 [98.1, 98.3]	98.4 [98.5, 98.7]
Left			
Any	99.9 [99.9, 100.0]	99.9 [99.9, 100.0]	99.9 [99.9, 100.0]
At Least Two	99.7 [99.7, 99.8]	99.8 [99.7, 99.8]	99.8 [99.8, 99.8]
All Three	98.0 [97.8, 98.1]	98.3 [98.1, 98.3]	98.8 [98.5, 98.7]

B.2 Jaccard Index

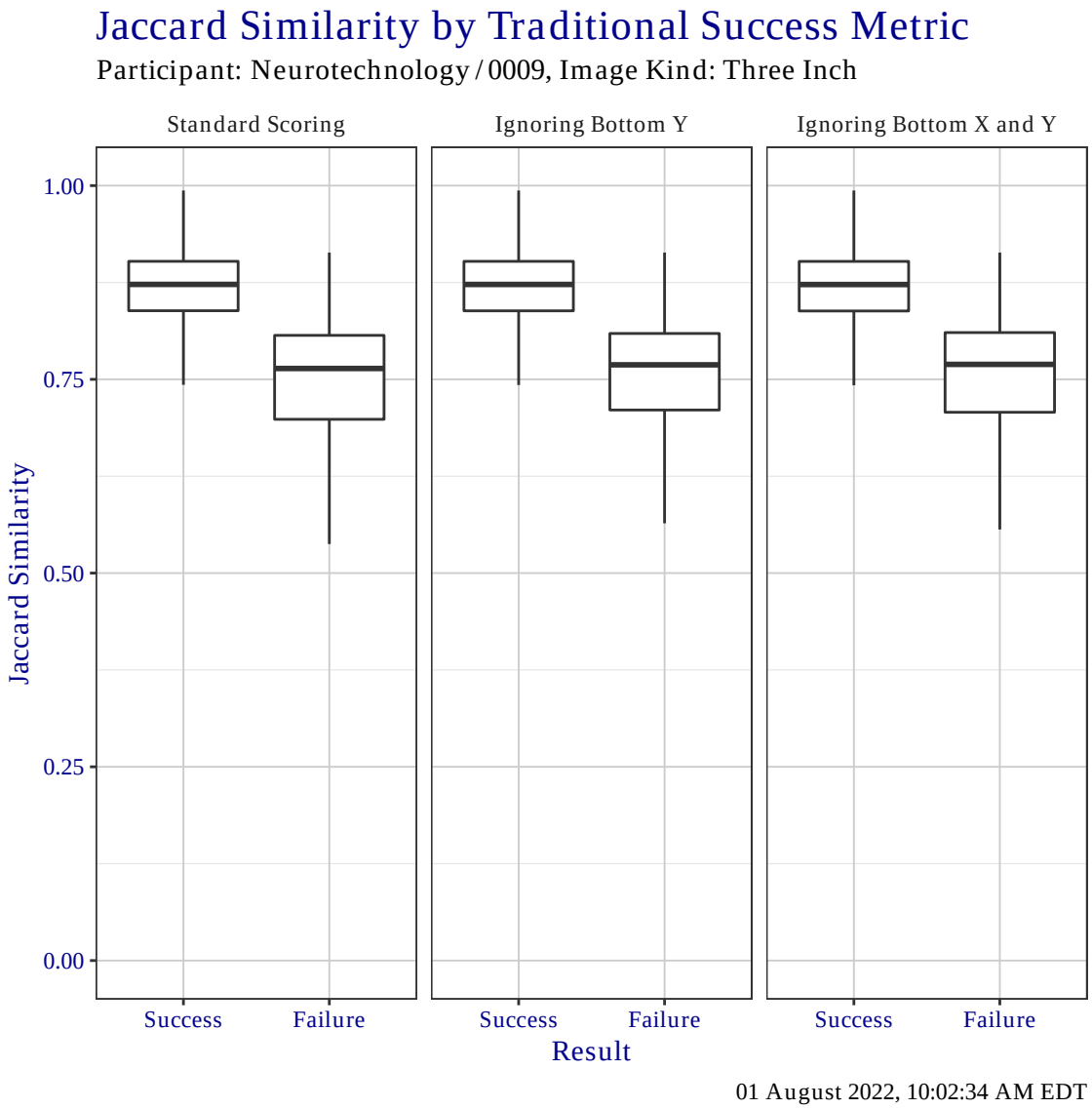

Figure 25: Boxplot of Jaccard similarity indices as compared to the traditional success metrics. Outliers have been removed for clarity.

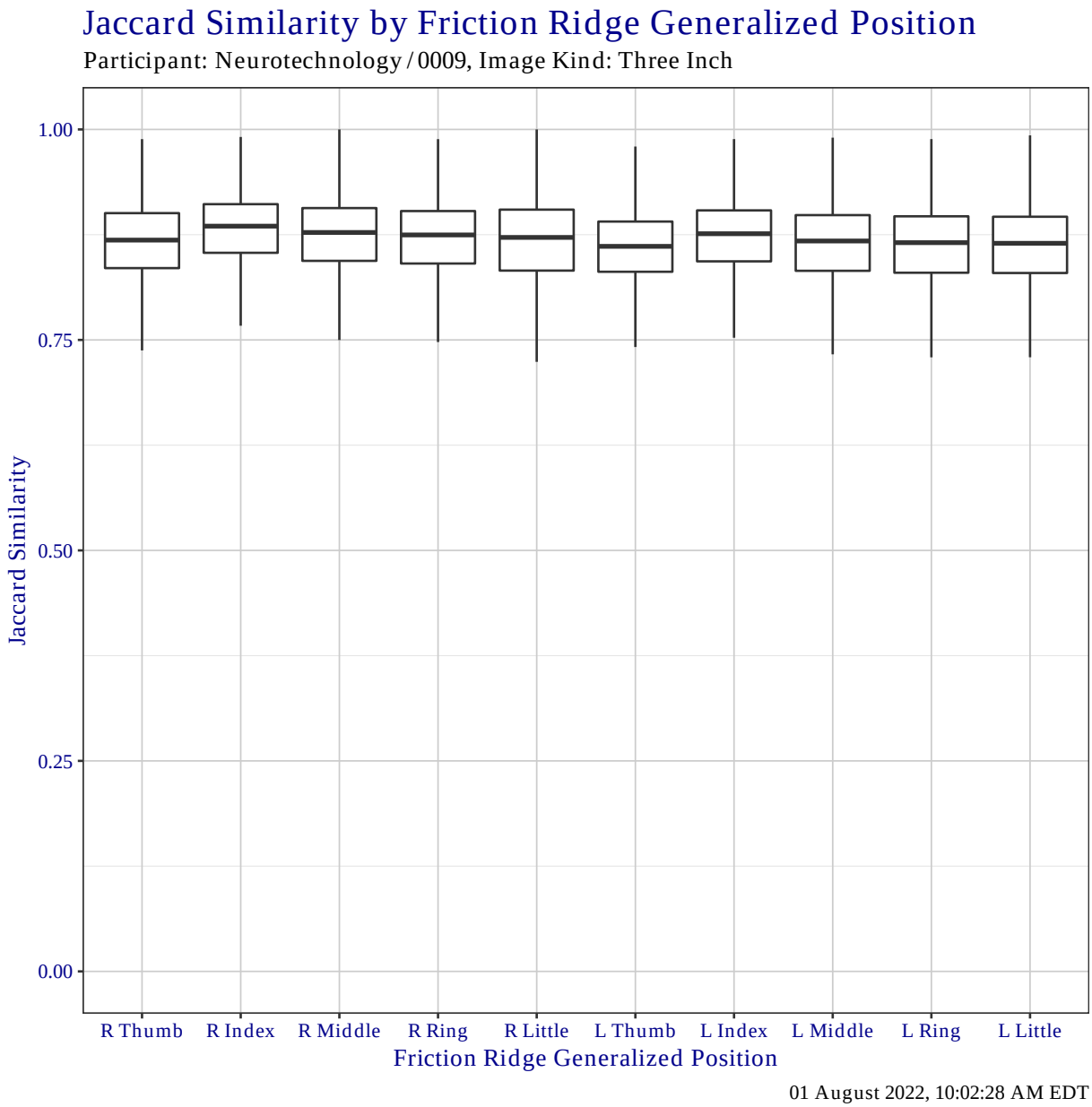

Figure 26: Boxplot of Jaccard similarity indices for each friction ridge generalized position. Outliers have been removed for clarity.

Table 62: 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	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
1	100.0	99.9	99.9	99.8	89.2	20.6	0.8
2	99.9	99.9	99.8	99.4	70.6	2.7	0.0
3	98.5	98.5	98.5	97.7	47.9	0.3	0.0
4	98.4	98.3	98.2	96.7	27.7	0.0	0.0
5	95.9	95.9	95.9	95.4	13.5	0.0	0.0
6	95.9	95.9	95.9	94.0	5.4	0	0
7	95.9	95.9	95.8	90.4	1.6	0	0
8	95.8	95.8	95.4	84.5	0.4	0	0
9	95.6	95.6	94.4	72.4	0.1	0	0
10	95.1	94.7	90.3	46.7	0.0	0	0

Table 63: 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
Right						
Thumb	0.2	0.1	0.4	8.4	65.5	25.4
Index	0.2	0.1	0.7	6.4	57.1	35.5
Middle	0.2	0.1	1.1	8.2	59.9	30.5
Ring	0.2	0.1	1.1	8.9	62.5	27.2
Little	0.3	0.1	1.1	11.7	58.3	28.5
Left						
Thumb	0.2	0.1	0.4	8.3	72.5	18.5
Index	0.1	0.0	0.1	7.3	64.3	28.2
Middle	0.2	0.0	0.3	10.1	65.7	23.7
Ring	0.2	0.0	0.6	11.0	65.4	22.8
Little	0.3	0.0	0.6	10.5	66.3	22.3

Table 64: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of all ten fingers of a ThreeInch slap.

Fingers	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
Right							
Any	99.9	99.9	99.9	99.6	75.1	13.2	0.5
At Least Two	98.5	98.5	98.5	95.9	44.4	1.1	0.0
At Least Three	98.5	98.4	98.1	93.2	19.2	0.1	0.0
At Least Four	98.3	98.2	97.2	87.4	5.3	0.0	0.0
All Five	94.5	94.3	91.3	66.1	0.6	0.0	0.0
Left							
Any	99.9	99.9	99.8	99.6	66.6	8.8	0.4
At Least Two	98.5	98.5	98.5	97.2	32.6	0.5	0.0
At Least Three	98.4	98.4	98.4	94.2	11.6	0.0	0.0
At Least Four	98.3	98.3	98.0	86.8	2.4	0.0	0.0
All Five	94.5	94.4	92.8	63.3	0.2	0.0	0.0

Table 65: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of index and middle fingers of a ThreeInch slap.

Fingers	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
Right							
Either Index or Middle	99.9	99.9	99.5	95.4	50.8	5.9	0.2
Both Index and Middle	99.7	99.6	98.2	87.6	15.2	0.2	0.0
Left							
Either Index or Middle	99.9	99.9	99.9	96.5	41.9	4.1	0.1
Both Index and Middle	99.8	99.7	99.4	85.4	10.0	0.1	0.0

Table 66: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of index, middle, and ring fingers of a ThreeInch slap.

Fingers	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
Right							
Any	99.9	99.9	99.8	96.5	59.6	7.9	0.3
At Least Two	99.9	99.8	99.1	93.0	27.3	0.5	0.0
All Three	99.7	99.5	97.4	83.3	6.4	0.0	0.0
Left							
Any	99.9	99.9	99.9	97.9	51.1	5.8	0.2
At Least Two	99.9	99.9	99.7	93.2	19.6	0.3	0.0
All Three	99.7	99.6	98.7	78.9	4.0	0.0	0

C Upper Palm ("FiveInch" Data)

C.1 Bootstrap Confidence for Segmentation Statistics

This section shows the same detailed results of segmentation of FiveInch data from Section 4.3, 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 67, results are shown of how successful Neurotechnology+0009 segmented fingers for each subject in the test corpus. Table 68 shows success for specific finger positions over the entire test corpus. Similarly, Table 69 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 70 shows success for combinations of all fingers, Table 72 for the all except the little finger, and Table 71 for just the index and middle fingers.

Table 67: 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	99.7 [99.3, 100.0]	99.7 [99.3, 100.0]	99.7 [99.3, 100.0]
2	99.1 [98.4, 99.7]	99.1 [98.3, 99.6]	99.3 [98.7, 99.9]
3	98.6 [97.6, 99.3]	98.6 [97.6, 99.3]	98.6 [97.6, 99.3]
4	96.6 [95.3, 97.8]	96.7 [95.5, 97.9]	96.7 [95.3, 97.9]
5	91.0 [89.1, 93.1]	91.2 [88.9, 93.1]	91.7 [89.7, 93.8]
6	82.9 [80.1, 85.5]	83.1 [80.2, 85.9]	84.3 [81.8, 86.8]
7	72.5 [69.2, 75.6]	72.6 [69.3, 75.6]	73.9 [71.0, 77.1]
8	53.9 [50.3, 57.6]	53.9 [50.5, 57.3]	57.3 [53.5, 61.0]

Table 68: 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
Right			
Index	88.4 [85.9, 90.7]	88.4 [86.2, 90.8]	88.8 [86.6, 91.1]
Middle	88.2 [85.8, 90.3]	88.2 [85.8, 90.4]	89.4 [87.2, 91.5]
Ring	88.7 [86.3, 91.0]	88.8 [86.4, 91.2]	89.5 [87.4, 91.5]
Little	85.5 [82.7, 88.0]	85.5 [83.0, 87.9]	88.0 [85.6, 90.2]
Left			
Index	87.8 [85.5, 90.2]	87.8 [85.3, 90.1]	88.2 [85.8, 90.5]
Middle	87.3 [84.9, 89.7]	87.4 [85.0, 89.9]	87.7 [85.4, 89.9]
Ring	90.5 [88.5, 92.4]	90.8 [88.9, 92.7]	91.1 [89.0, 93.1]
Little	83.4 [80.8, 86.1]	83.4 [80.8, 86.3]	84.5 [81.7, 87.0]

Table 69: 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
Index			
Either	95.8 [94.3, 97.1]	95.8 [94.2, 97.1]	95.8 [94.3, 97.1]
Both	79.1 [76.2, 82.2]	79.1 [76.2, 81.9]	79.8 [76.9, 82.6]
Middle			
Either	96.6 [95.3, 97.9]	96.6 [95.3, 97.9]	96.7 [95.5, 98.0]
Both	77.5 [74.6, 80.2]	77.6 [74.6, 80.5]	78.9 [76.2, 81.8]
Ring			
Either	97.2 [95.9, 98.4]	97.5 [96.2, 98.4]	97.8 [96.7, 98.8]
Both	80.5 [77.6, 83.3]	80.8 [77.9, 83.7]	81.4 [78.5, 84.1]
Little			
Either	95.7 [94.3, 97.1]	95.7 [94.2, 97.0]	96.3 [95.0, 97.5]
Both	71.9 [68.4, 75.0]	71.9 [68.5, 75.1]	74.8 [71.5, 77.9]

Table 70: Percentage of segmentation success by hand for combinations of all eight fingers of a FiveInch 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
Right			
Any	98.8 [98.3, 99.3]	98.8 [98.3, 99.4]	98.8 [98.3, 99.4]
At Least Two	94.8 [93.2, 95.6]	94.8 [93.4, 95.7]	95.2 [93.8, 96.1]
At Least Three	87.0 [85.5, 88.8]	87.0 [85.3, 88.8]	87.9 [86.3, 89.6]
All Four	70.2 [67.2, 71.8]	70.3 [67.3, 71.9]	73.8 [69.7, 74.0]
Left			
Any	98.8 [98.3, 99.3]	98.9 [98.3, 99.4]	98.9 [98.3, 99.4]
At Least Two	94.0 [93.2, 95.6]	94.3 [93.4, 95.7]	94.7 [93.8, 96.1]
At Least Three	87.4 [85.5, 88.8]	87.4 [85.3, 88.8]	87.9 [86.3, 89.6]
All Four	68.7 [67.2, 71.8]	68.8 [67.3, 71.9]	69.9 [69.7, 74.0]

Table 71: 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
Right			
Either Index or Middle	94.7 [93.6, 95.9]	94.7 [93.6, 95.9]	94.9 [93.8, 96.0]
Both Index and Middle	81.9 [79.0, 83.0]	81.9 [79.0, 83.0]	83.2 [80.0, 83.9]
Left			
Either Index or Middle	94.8 [93.6, 95.9]	95.0 [93.6, 95.9]	95.1 [93.8, 96.0]
Both Index and Middle	80.2 [79.0, 83.0]	80.2 [79.0, 83.0]	80.8 [80.0, 83.9]

Table 72: 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
Right			
Any	97.5 [96.5, 98.2]	97.5 [96.7, 98.2]	97.6 [96.7, 98.3]
At Least Two	91.2 [89.6, 92.4]	91.2 [89.6, 92.6]	91.8 [90.0, 92.9]
All Three	76.6 [74.7, 79.0]	76.7 [75.1, 79.2]	78.3 [76.2, 80.4]
Left			
Any	97.2 [96.5, 98.2]	97.5 [96.7, 98.2]	97.5 [96.7, 98.3]
At Least Two	90.8 [89.6, 92.4]	91.0 [89.6, 92.6]	91.4 [90.0, 92.9]
All Three	77.5 [74.7, 79.0]	77.6 [75.1, 79.2]	78.1 [76.2, 80.4]

C.2 Jaccard Index

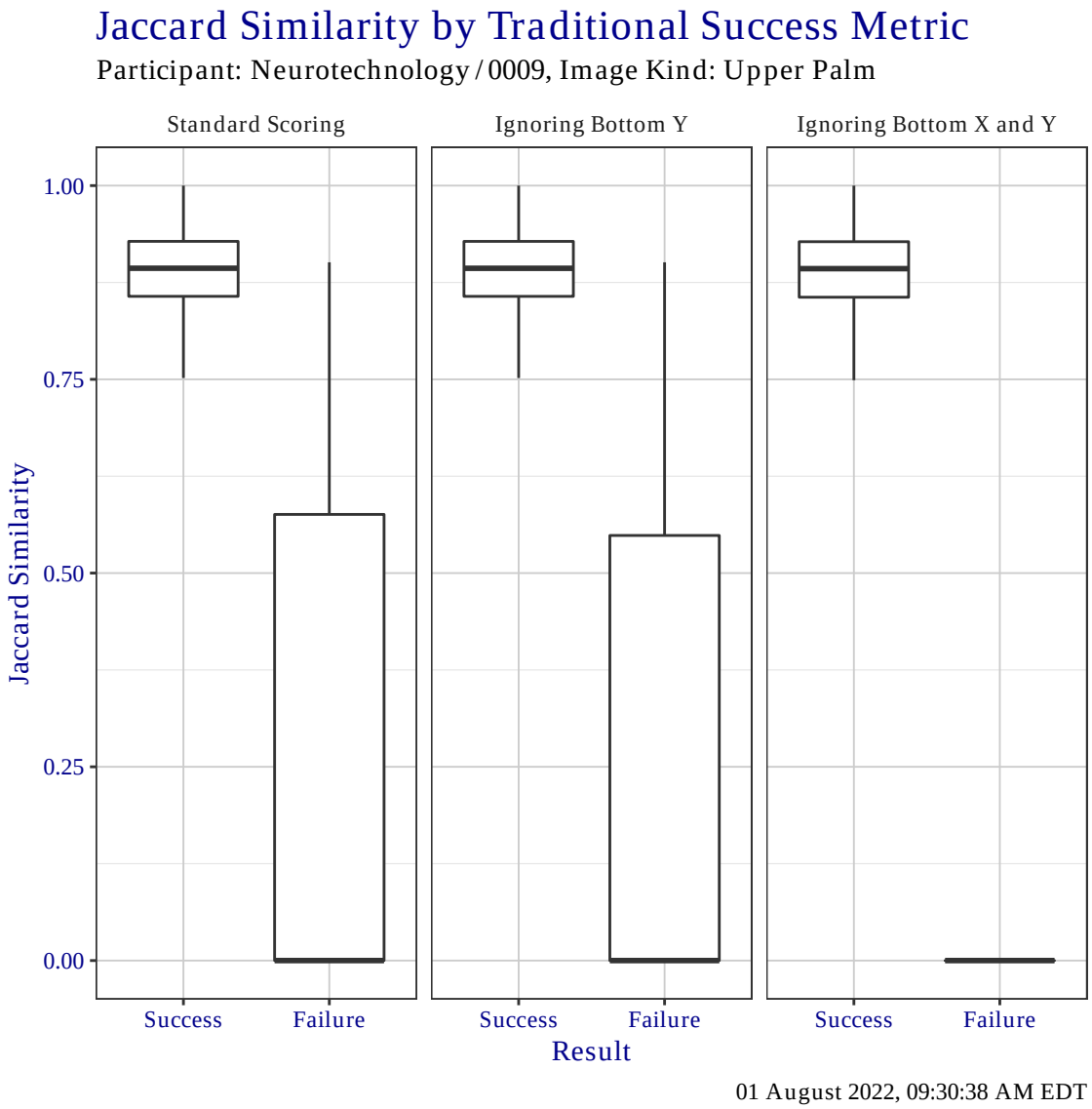

Figure 27: Boxplot of Jaccard similarity indices as compared to the traditional success metrics. Outliers have been removed for clarity.

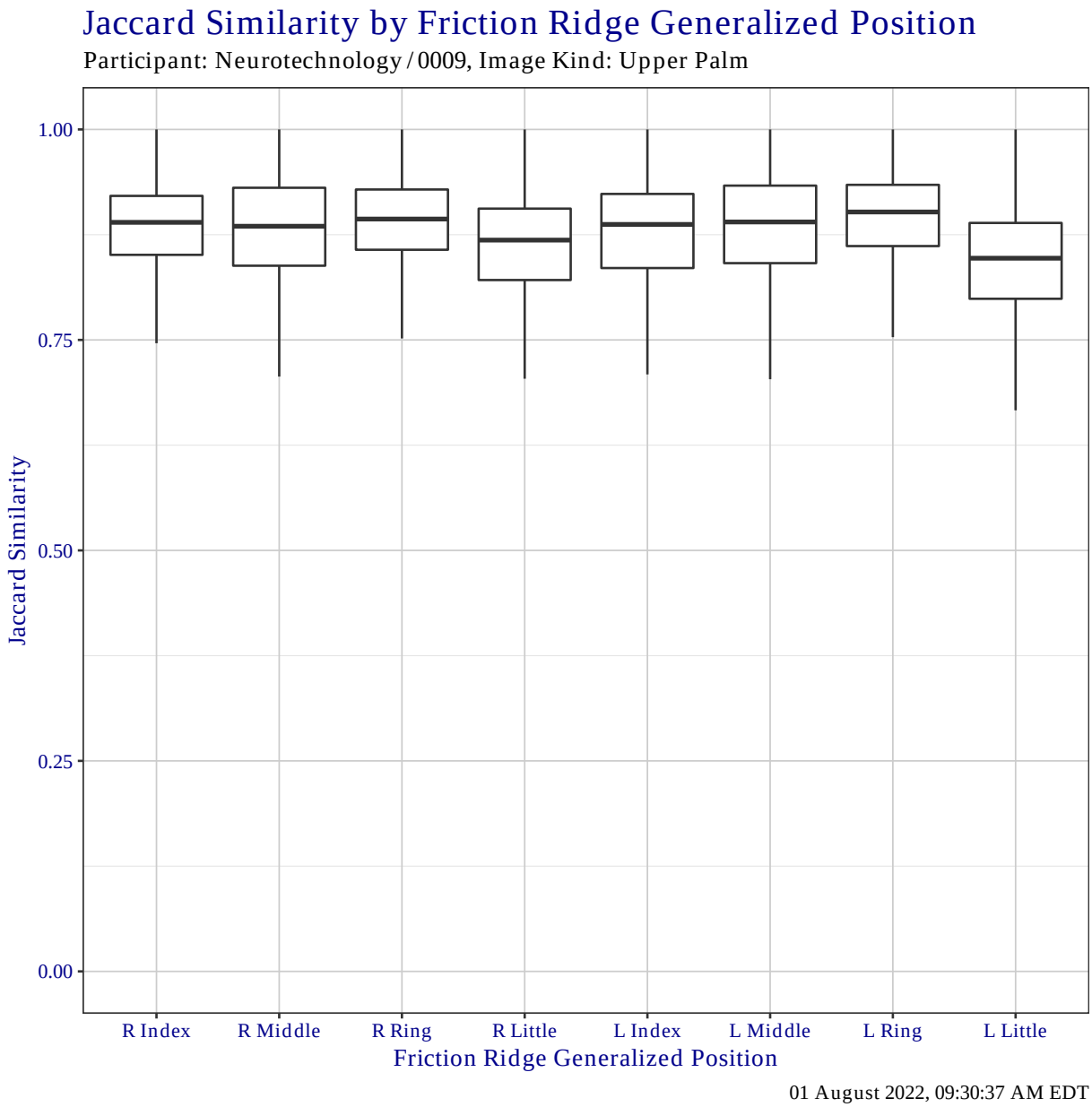

Figure 28: Boxplot of Jaccard similarity indices for each friction ridge generalized position. Outliers have been removed for clarity.

Table 73: 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	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
1	99.7	99.7	99.7	99.6	91.7	40.7	27.7
2	99.6	99.6	99.6	98.7	78.0	21.7	19.9
3	99.1	99.1	98.8	97.5	58.2	17.5	17.4
4	97.5	97.4	97.0	95.0	37.3	14.0	13.7
5	92.6	92.6	92.2	88.4	21.1	10.1	10.1
6	86.0	85.8	85.1	79.3	11.9	7.5	7.5
7	78.4	77.9	76.7	64.3	7.1	6.3	6.3
8	66.9	66.4	63.8	44.4	4.2	4.1	4.1

Table 74: 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
Right						
Index	9.6	0.3	0.5	3.1	43.7	42.8
Middle	9.3	0.3	0.3	5.3	44.7	40.1
Ring	9.6	0	0.4	3.1	42.8	44.1
Little	8.8	0.1	0.7	7.2	53.3	29.9
Left						
Index	10.8	0.1	0.9	4.6	41.3	42.3
Middle	10.5	0	0.9	4.5	42.0	42.1
Ring	7.5	0.3	0.7	2.9	36.9	51.7
Little	8.4	0.4	1.2	15.4	55.8	18.8

Table 75: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of all ten fingers of a FiveInch slap.

Fingers	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
Right							
Any	98.8	98.8	98.7	98.1	78.9	27.8	21.1
At Least Two	95.6	95.6	95.6	93.9	47.9	15.8	15.3
At Least Three	89.1	88.8	88.6	85.1	21.9	11.2	11.2
All Four	79.3	78.9	77.4	64.5	8.4	6.9	6.9
Left							
Any	99.1	99.1	98.8	98.4	77.7	29.3	21.9
At Least Two	95.5	95.4	94.8	92.4	48.8	15.3	14.5
At Least Three	90.2	89.8	89.1	82.6	21.0	10.7	10.7
All Four	78.1	77.9	75.6	57.4	7.4	6.0	6.0

Table 76: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of index and middle fingers of a FiveInch slap.

Fingers	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
Right							
Either Index or Middle	95.5	95.3	95.1	94.1	61.6	23.0	19.9
Both Index and Middle	85.6	85.2	84.7	77.3	21.4	11.7	11.4
Left							
Either Index or Middle	95.5	95.4	94.8	93.2	61.1	25.1	20.3
Both Index and Middle	83.3	83.3	82.0	74.4	23.2	10.9	10.7

Table 77: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of index, middle, and ring fingers of a FiveInch slap.

Fingers	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
Right							
Any	97.7	97.7	97.6	96.9	75.1	26.1	20.7
At Least Two	92.7	92.6	92.3	90.2	37.2	15.2	14.9
All Three	81.1	80.7	79.9	71.3	14.8	9.8	9.8
Left							
Any	97.7	97.7	97.5	96.9	75.7	28.6	21.4
At Least Two	92.4	92.0	91.4	88.6	44.3	14.7	14.2
All Three	81.0	81.0	79.4	70.7	16.0	10.1	10.1

D Full Palm ("EightInch" Data)

D.1 Bootstrap Confidence for Segmentation Statistics

NOTE: *The following segmentation statistics are based on a limited subset (approximately 15%) of the anticipated Full Palm dataset. This analysis will be updated as soon as NIST can obtain the remainder of the dataset.*

This section shows the same detailed results of segmentation of EightInch data from Section 5.3, 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 78, results are shown of how successful Neurotechnology+0009 segmented fingers for each subject in the test corpus. Table 79 shows success for specific finger positions over the entire test corpus. Similarly, Table 80 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 81 shows success for combinations of all fingers, Table 83 for the all except the little finger, and Table 82 for just the index and middle fingers.

Table 78: 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	100.0 [100.0, 100.0]	100.0 [100.0, 100.0]	100.0 [100.0, 100.0]
2	100.0 [100.0, 100.0]	100.0 [100.0, 100.0]	100.0 [100.0, 100.0]
3	100.0 [100.0, 100.0]	100.0 [100.0, 100.0]	100.0 [100.0, 100.0]
4	99.8 [99.4, 100.0]	99.8 [99.4, 100.0]	99.9 [99.7, 100.0]
5	98.9 [98.0, 99.5]	98.9 [98.2, 99.5]	99.0 [98.3, 99.5]
6	98.4 [97.5, 99.2]	98.4 [97.5, 99.2]	98.4 [97.5, 99.2]
7	97.2 [96.1, 98.3]	97.5 [96.3, 98.5]	97.6 [96.4, 98.5]
8	89.5 [87.7, 91.4]	89.7 [87.6, 91.6]	90.8 [88.7, 92.6]

Table 79: 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
Right			
Index	97.6 [96.4, 98.5]	97.7 [96.7, 98.7]	97.7 [96.7, 98.6]
Middle	97.7 [96.6, 98.6]	97.7 [96.7, 98.6]	98.0 [97.0, 98.9]
Ring	98.4 [97.6, 99.2]	98.5 [97.6, 99.3]	98.7 [97.9, 99.4]
Little	98.2 [97.2, 99.0]	98.2 [97.2, 99.0]	98.6 [97.7, 99.3]
Left			
Index	98.6 [97.8, 99.3]	98.6 [97.8, 99.3]	98.7 [97.9, 99.4]
Middle	97.9 [96.9, 98.9]	97.9 [96.9, 98.9]	97.9 [96.9, 98.9]
Ring	97.9 [96.9, 98.9]	97.9 [96.9, 98.9]	98.3 [97.4, 99.1]
Little	97.5 [96.3, 98.4]	97.6 [96.6, 98.5]	97.6 [96.6, 98.6]

Table 80: 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
Index			
Either	100.0 [100.0, 100.0]	100.0 [100.0, 100.0]	100.0 [100.0, 100.0]
Both	96.2 [94.9, 97.5]	96.3 [95.1, 97.6]	96.4 [95.2, 97.6]
Middle			
Either	99.7 [99.2, 100.0]	99.7 [99.2, 100.0]	99.7 [99.2, 100.0]
Both	96.0 [94.6, 97.2]	96.0 [94.5, 97.4]	96.3 [95.1, 97.6]
Ring			
Either	99.5 [99.1, 99.9]	99.7 [99.2, 100.0]	99.8 [99.4, 100.0]
Both	96.8 [95.4, 97.9]	96.8 [95.5, 98.0]	97.2 [96.1, 98.4]
Little			
Either	100.0 [100.0, 100.0]	100.0 [100.0, 100.0]	100.0 [100.0, 100.0]
Both	95.6 [94.3, 96.9]	95.7 [94.4, 97.0]	96.2 [94.8, 97.5]

Table 81: Percentage of segmentation success by hand for combinations of all eight fingers of a EightInch 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
Right			
Any	99.4 [99.2, 99.8]	99.4 [99.2, 99.8]	99.5 [99.3, 99.9]
At Least Two	99.2 [98.9, 99.7]	99.2 [98.9, 99.7]	99.2 [98.9, 99.7]
At Least Three	98.9 [98.2, 99.3]	98.9 [98.3, 99.3]	99.0 [98.3, 99.3]
All Four	94.4 [93.1, 95.3]	94.6 [93.4, 95.5]	95.4 [94.0, 96.0]
Left			
Any	99.7 [99.2, 99.8]	99.7 [99.2, 99.8]	99.7 [99.3, 99.9]
At Least Two	99.4 [98.9, 99.7]	99.4 [98.9, 99.7]	99.4 [98.9, 99.7]
At Least Three	98.7 [98.2, 99.3]	98.7 [98.3, 99.3]	98.7 [98.3, 99.3]
All Four	94.1 [93.1, 95.3]	94.3 [93.4, 95.5]	94.7 [94.0, 96.0]

Table 82: 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
Right			
Either Index or Middle	99.2 [99.0, 99.7]	99.2 [99.0, 99.7]	99.2 [99.0, 99.7]
Both Index and Middle	96.1 [95.6, 97.4]	96.2 [95.7, 97.5]	96.6 [95.9, 97.6]
Left			
Either Index or Middle	99.5 [99.0, 99.7]	99.5 [99.0, 99.7]	99.5 [99.0, 99.7]
Both Index and Middle	97.0 [95.6, 97.4]	97.0 [95.7, 97.5]	97.1 [95.9, 97.6]

Table 83: 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
Right			
Any	99.4 [99.1, 99.8]	99.4 [99.1, 99.8]	99.4 [99.1, 99.8]
At Least Two	99.0 [98.4, 99.4]	99.0 [98.4, 99.4]	99.0 [98.4, 99.4]
All Three	95.3 [94.7, 96.6]	95.5 [94.8, 96.7]	96.1 [95.4, 97.1]
Left			
Any	99.5 [99.1, 99.8]	99.5 [99.1, 99.8]	99.5 [99.1, 99.8]
At Least Two	98.9 [98.4, 99.4]	98.9 [98.4, 99.4]	98.9 [98.4, 99.4]
All Three	96.1 [94.7, 96.6]	96.1 [94.8, 96.7]	96.6 [95.4, 97.1]

D.2 Jaccard Index

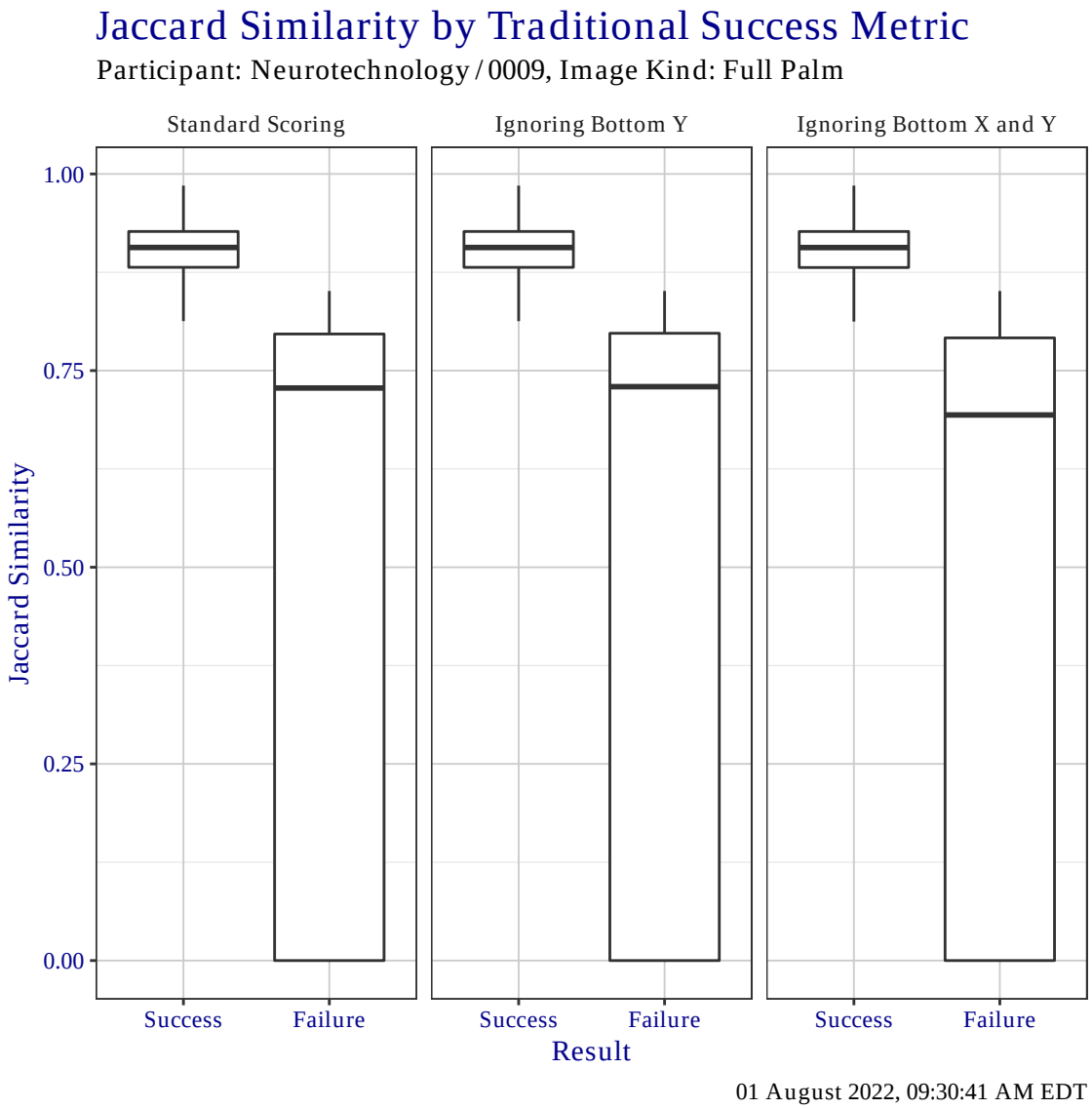

Figure 29: Boxplot of Jaccard similarity indices as compared to the traditional success metrics. Outliers have been removed for clarity.

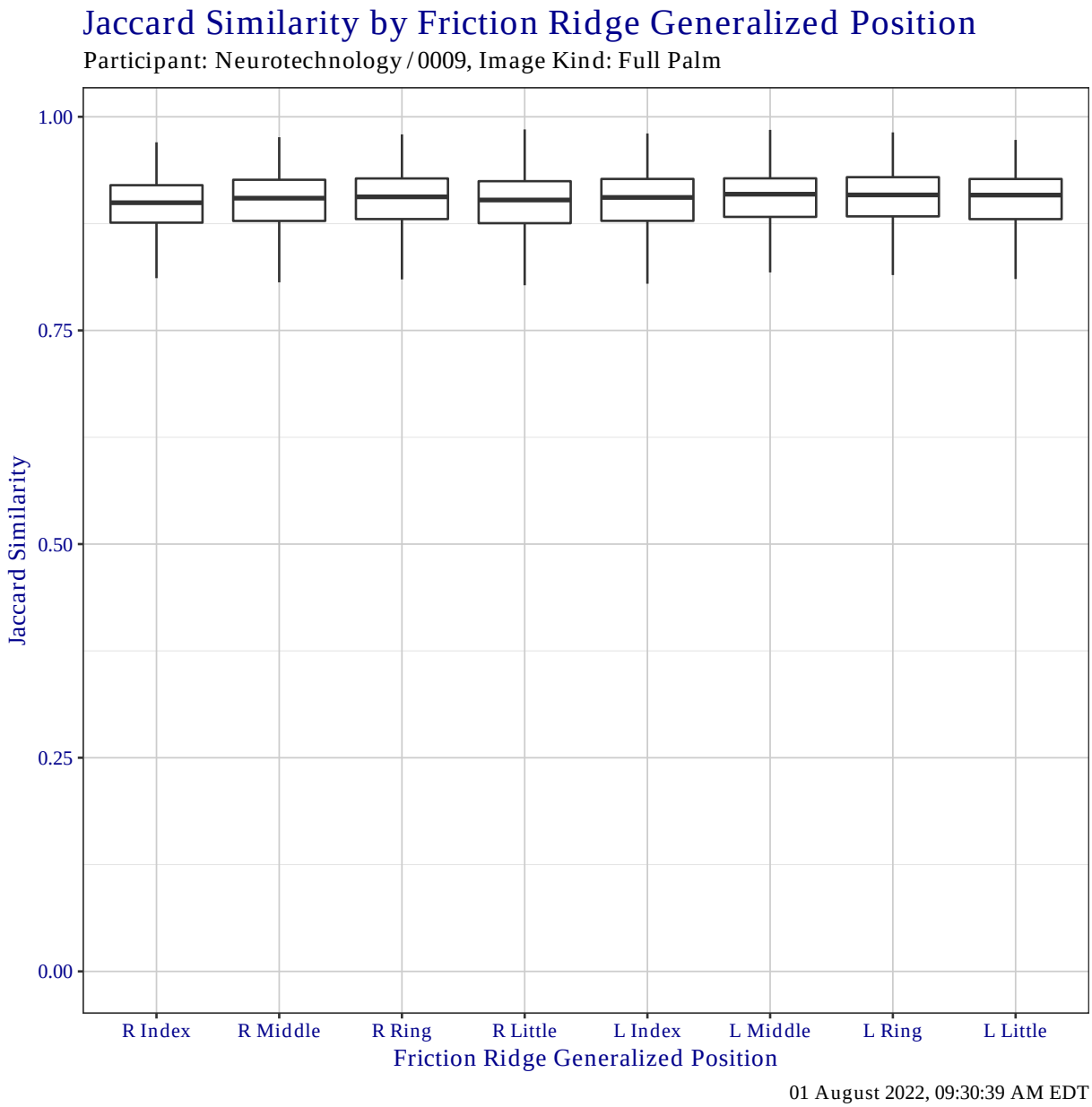

Figure 30: Boxplot of Jaccard similarity indices for each friction ridge generalized position. Outliers have been removed for clarity.

Table 84: 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	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
1	100.0	100.0	100.0	100.0	98.9	36.7	0.6
2	100.0	100.0	100.0	100.0	93.3	9.7	0
3	100.0	100.0	100.0	99.9	85.1	1.7	0
4	100.0	100.0	100.0	99.8	70.1	0.3	0
5	99.2	99.2	99.2	98.2	52.6	0.1	0
6	98.9	98.9	98.9	97.4	31.6	0	0
7	98.5	98.5	98.2	94.1	14.5	0	0
8	96.7	96.6	94.8	84.9	2.9	0	0

Table 85: 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
Right						
Index	1.5	0.1	0.2	2.1	47.0	49.1
Middle	1.0	0	0.1	2.1	40.1	56.7
Ring	0.6	0	0.6	2.4	39.2	57.2
Little	0.5	0	0.3	2.1	44.1	53.0
Left						
Index	0.9	0	0	2.0	41.9	55.2
Middle	0.8	0	0.3	1.4	36.8	60.7
Ring	0.8	0	0.1	2.8	37.3	59.0
Little	0.7	0	0.3	2.1	38.7	58.2

Table 86: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of all ten fingers of a EightInch slap.

Fingers	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
Right							
Any	99.7	99.7	99.7	99.4	91.3	20.9	0.1
At Least Two	99.4	99.4	99.4	98.7	71.3	2.8	0.0
At Least Three	99.2	99.2	99.1	97.1	39.7	0.5	0.0
All Four	98.2	98.0	96.9	91.1	13.8	0.0	0.0
Left							
Any	99.7	99.7	99.7	99.5	92.2	22.4	0.5
At Least Two	99.4	99.4	99.4	99.2	75.1	2.0	0.0
At Least Three	99.3	99.3	99.3	97.8	47.5	0.0	0.0
All Four	98.4	98.4	97.6	91.3	18.3	0.0	0.0

Table 87: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of index and middle fingers of a EightInch slap.

Fingers	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
Right							
Either Index or Middle	99.2	99.2	99.1	98.5	74.3	9.4	0
Both Index and Middle	98.3	98.2	97.9	94.4	31.5	0.3	0
Left							
Either Index or Middle	99.5	99.5	99.5	99.2	78.0	10.2	0.3
Both Index and Middle	98.7	98.7	98.4	95.4	37.8	0.3	0

Table 88: Percentage of segmentation obtaining a Jaccard index in the indicated ranges, by hand, for combinations of index, middle, and ring fingers of a EightInch slap.

Fingers	≥0.5	≥0.6	≥0.7	≥0.8	≥0.9	≥0.95	≥0.98
Right							
Any	99.4	99.4	99.4	99.1	85.7	16.3	0
At Least Two	99.2	99.2	99.1	97.7	55.7	1.4	0
All Three	98.3	98.2	97.4	92.5	21.5	0.1	0
Left							
Any	99.5	99.5	99.5	99.4	87.6	16.7	0.5
At Least Two	99.3	99.3	99.3	98.7	60.7	1.1	0
All Three	98.6	98.6	98.2	92.8	26.6	0	0