Signature Complexity

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DOCX https://www.dropbox.com/s/kor5zfhe26rucpe/SignatureComplexity.docx?dl=0
PDF https://www.dropbox.com/s/0z93iqcbyqt5sub/SignatureComplexity.pdf?dl=0

INTRODUCTION

A signature that is normally placed on paper can also be placed on a paper that is on top of a pen tablet using an inking, digital pen. (When lacking pen tablet you can use your finger on a touch tablet or even a computer mouse).

This recording will yield both a conventional wet-ink signature and an “electronic signature”. An electronic signature contains the movement dynamic. The movement dynamics open doors to many novel applications.

(1) Measuring Signature Complexity

Complexity is interpreted as the difficulty of forgery without detection by a forensic document examiner (FDE).

1 = Easy,
2 = Fairly easy,
3 = Medium,
4 = Difficult, and
5 = Very difficult.

Miriam Angel et al. (2017) model of complexity explains 71%-79% of the variation of the visual complexity score by experienced FDEs.

(2) Measuring Signature Genuinity

A single signature placed on a pen tablet can be identified as a forgery by checking for adherence to movement isochrony.

0 = Forgery
1 = Genuine

Caligiuri et al. (2012) proposed an isochrony test to discriminate between genuine and forged signatures.

This document describes how you can instantly measure signature complexity and genuinity using NeuroScript® Movalyzer® handwriting movement software for MS Windows.

Usage: Place a signature on a pen tablet. The External App will instantly estimate the signature’s Complexity (as a scalar 1-5) and Genuinity (as a scalar 0-1).

References

Miriam Angel, Michael P. Caligiuri, Melvin Cavanaugh (2017). Kinematic Models of Subjective Complexity in Handwritten Signatures. Journal of the American Society of Questioned Document Examiners, Inc. Volume 20, Number 2, December 2017. Pp. 3-10.

Michael P.Caligiuri, Linton A.Mohammed, Bryan Found, Doug Rogers. Nonadherence to the isochrony principle in forged signatures. Forensic Science International Volume 223, Issues 1–3, 30 November 2012, Pages 228-232.

Related References

Alewijnse, L.C., van den Heuvel, E.C., & Stoel, R.D. (2011). Analysis of signature complexity. Journal of Forensic Document Examination, 21, 37-49.

Found, B. & Rogers, D (1996). The forensic investigation of signature complexity. In M. Simner, G. Leedham & A. Thomassen (Eds.), Handwriting and Drawing Research: Basic and Applied issues, (pp. 483 - 492). Amsterdam: IOS Press.

Harralson, Heidi H., Waites, Elizabeth, Will, Emily J. A Survey of Forensic Handwriting Examination Research in Response to the NAS Report. Céline Rémi; Lionel Prévost; Eric Anquetil. 17th Biennial Conference of the International Graphonomics Society, Jun 2015, Pointe-à-Pitre, Guadeloupe. 2015, Drawing, Handwriting Processing Analysis: New Advances and Challenges. https://hal.univ-antilles.fr/hal-01165905/document

Pepe, A.L., Rogers, D., & Sita, J. (2012). A consideration of signature complexity using simulators' gaze behaviour. Journal of Forensic Document Examination, 22, 5-13.

SETUP

1. If Movalyzer6.1 not installed
Download Movalyzer from www.neuroscriptsoftware.com and register
Run Movalyzer.msi
Email Activation Request Code
Setup instructions will be emailed.

2. Download Movalyzer Export File (SCO.MEF):
https://www.dropbox.com/s/ldgk4dpi3cxie8h/SCO.MEF?dl=0.

3. Import Experiment Into Movalyzer
In Movalyzer: File >Import >Import Experiment
If significant clashes, create first new user:
File >Users >Create New >… >Open

4a. Running from Scratch in a new Movalyzer User.
4a.1. Expand Experiment SCO >Expand Groups >Rightclick Subjects under the appropriate signature group >Add Subject >… >Add
4a.2. Rightclick your subject >Run Experiment
4a.3. To chart the signature, wait till you see: External process continues to run. Wait? Click No.
Then double click on the trial just recorded.

4b. Running in Existing Experiment in in existing User
Rightclick your experiment >Properties >Processing >Segmentation >Uncheck: Submovement analysis (Changing this requires reprocessing all trials).
4b.1. Rightclick your experiment >Properties >External Apps >At Post-Feature Extraction:
4b.1.1. Application=Batch
4b.1.2. Script=SignatureComplexity.bat (or an experiment-specific file – See 4c.)
4b.2. Edit Script >Scroll down till:
set grouptext=…, set groupmixed=…, set groupstylized=…
and insert the proper group names.
If 3 signature types are under one group, use that Group ID for all 3.
4b.3. Double click on the trial to be processed to chart it.
4b.4. Reprocess existing data:
Rightclick a particular subject or trial >Reprocess Trials.
Otherwise follow 4a.

4c. Running in Multiple Existing Experiments in Existing User
4c.1. Copy SignatureComplexity.bat to the existing user, say U01, C:\users\public\documents\neuroscript\U01\Scripts\ specifically for experiment, say E01, to E01SignatureComplexity.bat.
Then proceed at 4b.

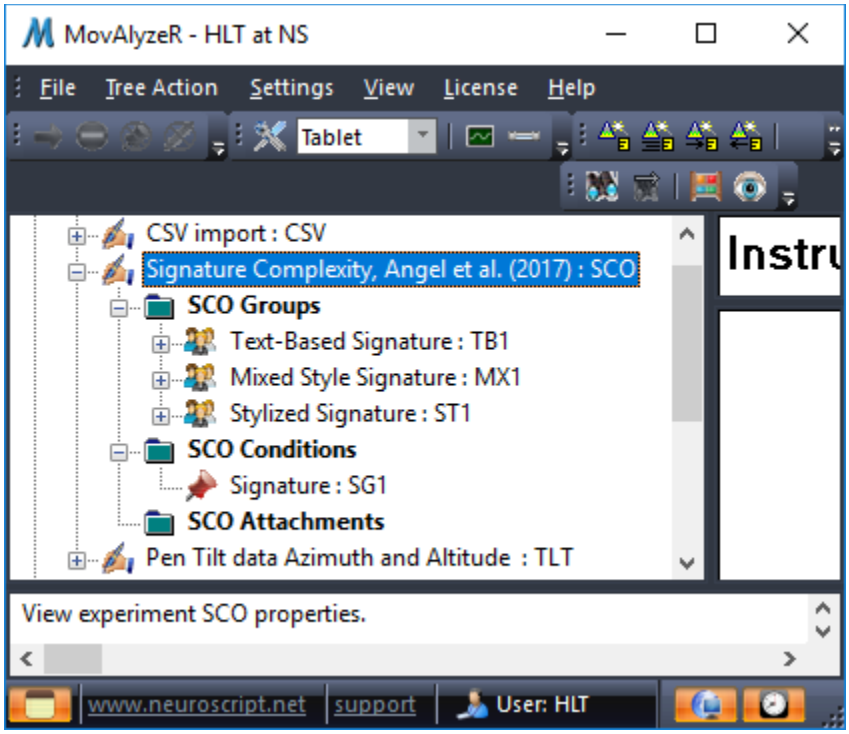
4d. Running in Existing Experiment in a Different User (e.g., U02), Than Where Experiment SCO Was imported (e.g., U01).
4d.1. Copy all files from C:\users\public\documents\neuroscript\U01\Scripts\
to C:\users\public\documents\neuroscript\U02\Scripts\
Then proceed at 4b.

A. SETUP (In Detail)

1. To run SignatureComplexity on existing or recorded signatures, download Movalyzer from www.neuroscriptsoftware.com.
2. Download SCO.MEF from https://www.dropbox.com/s/ldgk4dpi3cxie8h/SCO.MEF?dl=0.
3. Import SCO.MEF into Movalyzer (under your user ID): File >Import Experiment >Import
If conflicts, abort, define a new User and import.
If you wish to use the external app in an existing experiment
4. To view the present document: Expand Experiment SCO >Attachments >View

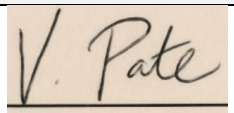
B. RUN DEMONSTRATOR

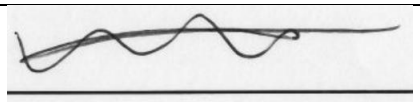
1. Expand Experiment SCO



NOTE: We use a contrast-rich Movalyzer application look:
View >Application Look >Visual Manager >Carbon

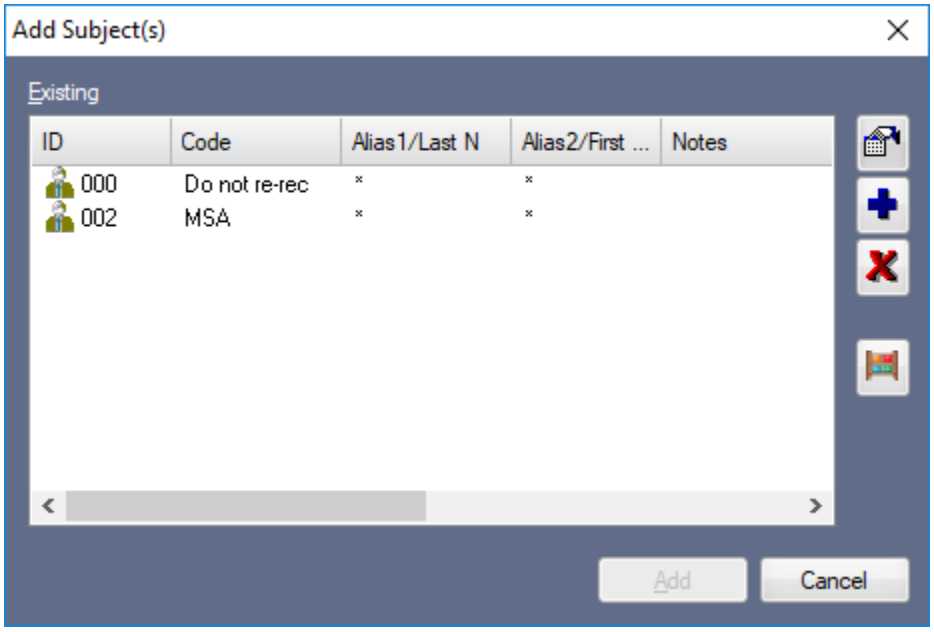
2. Decide which type of signature you wish to record. The model estimators have been optimized for three types of signatures:

Signature Group	Example	Group ID in Experiment SCO
Text-based		TB1
Mixed		MX1

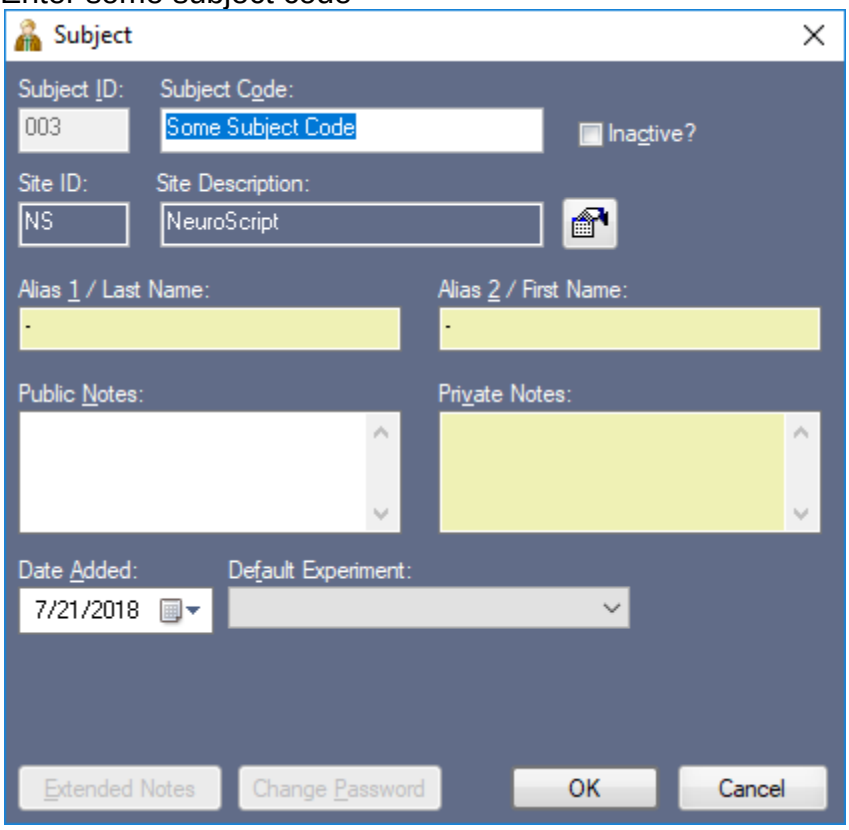
Stylized.		ST1

You can edit the Group IDs in SignatureComplexity.bat. This procedure has multiple error messages plus instructions how to fix.

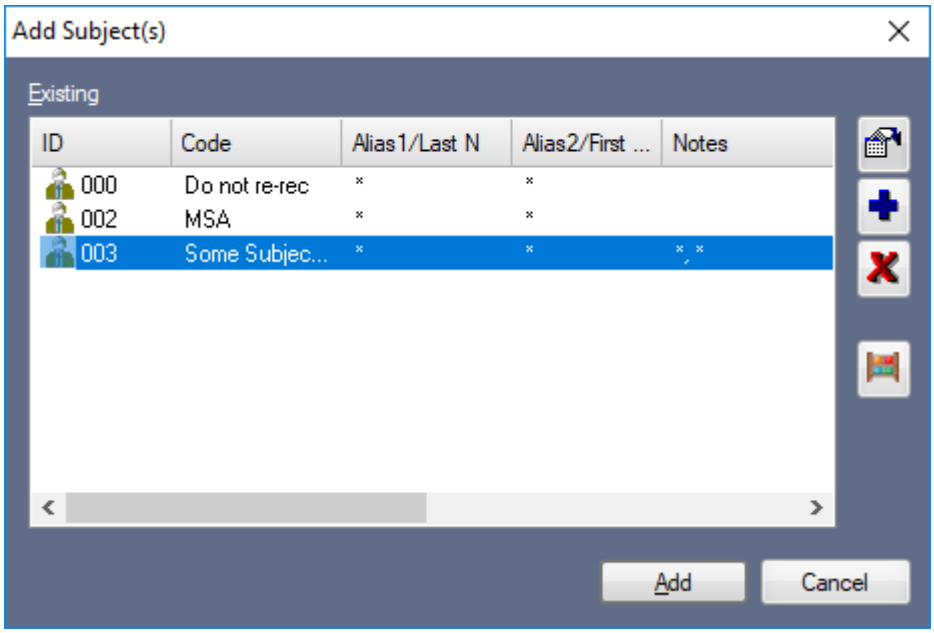
3. Rightclick the appropriate signature group >Add Subject



Click Add (+ sign)
Enter some subject code

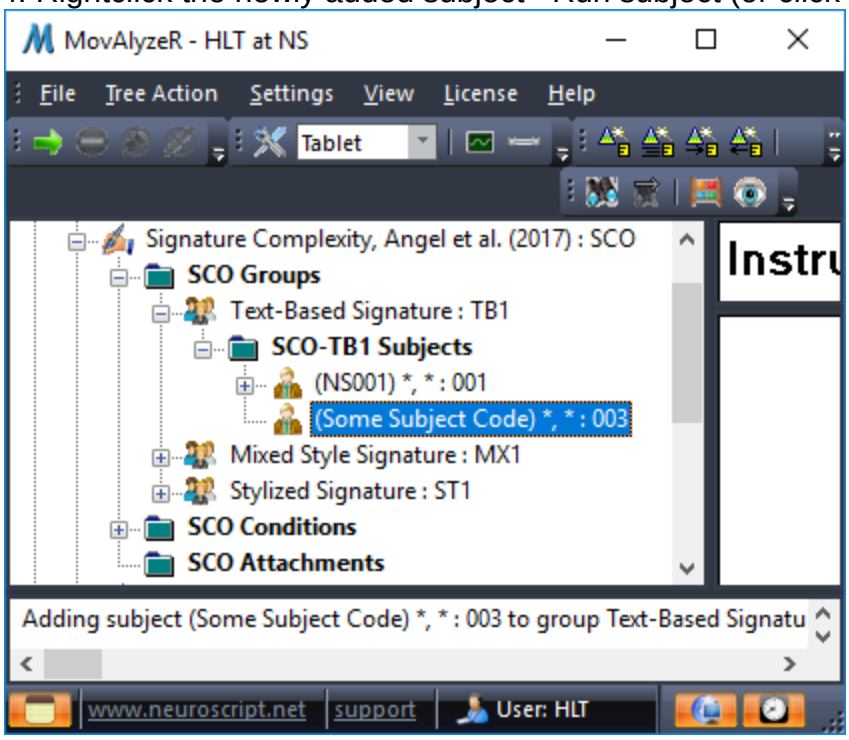


OK

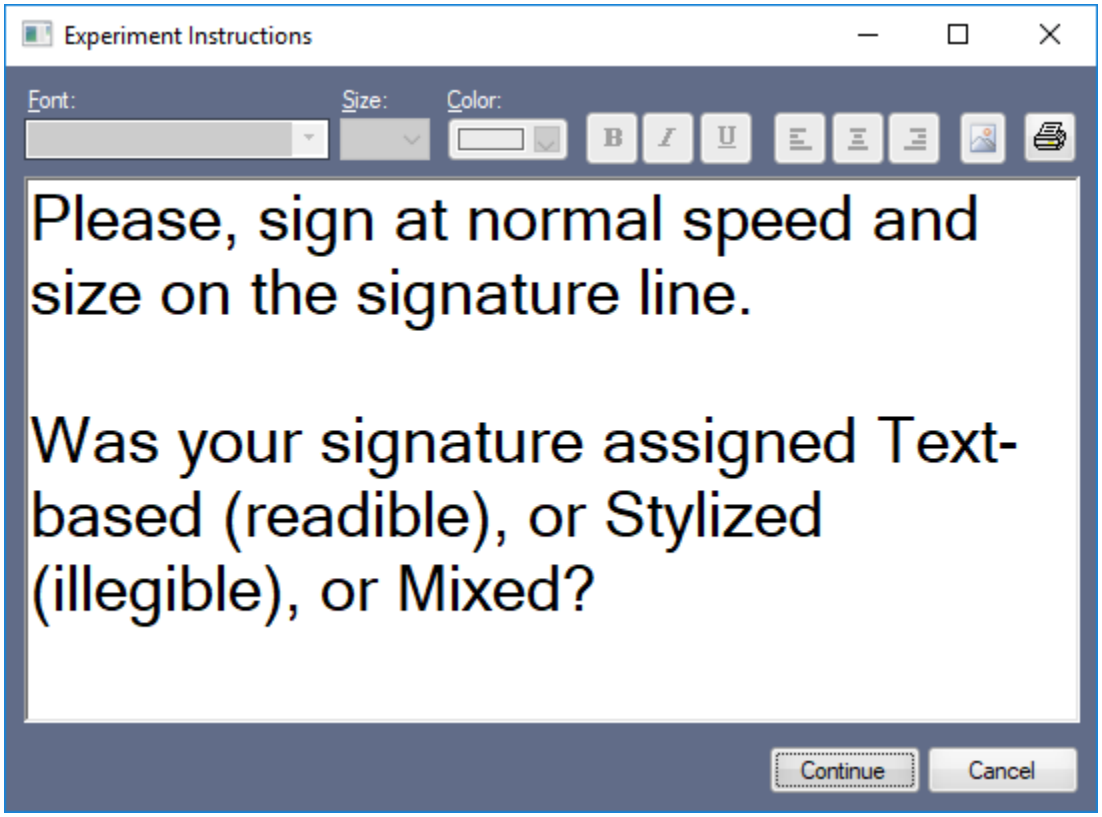


Click Add

4. Rightclick the newly added subject >Run subject (or click it and Hit F9).

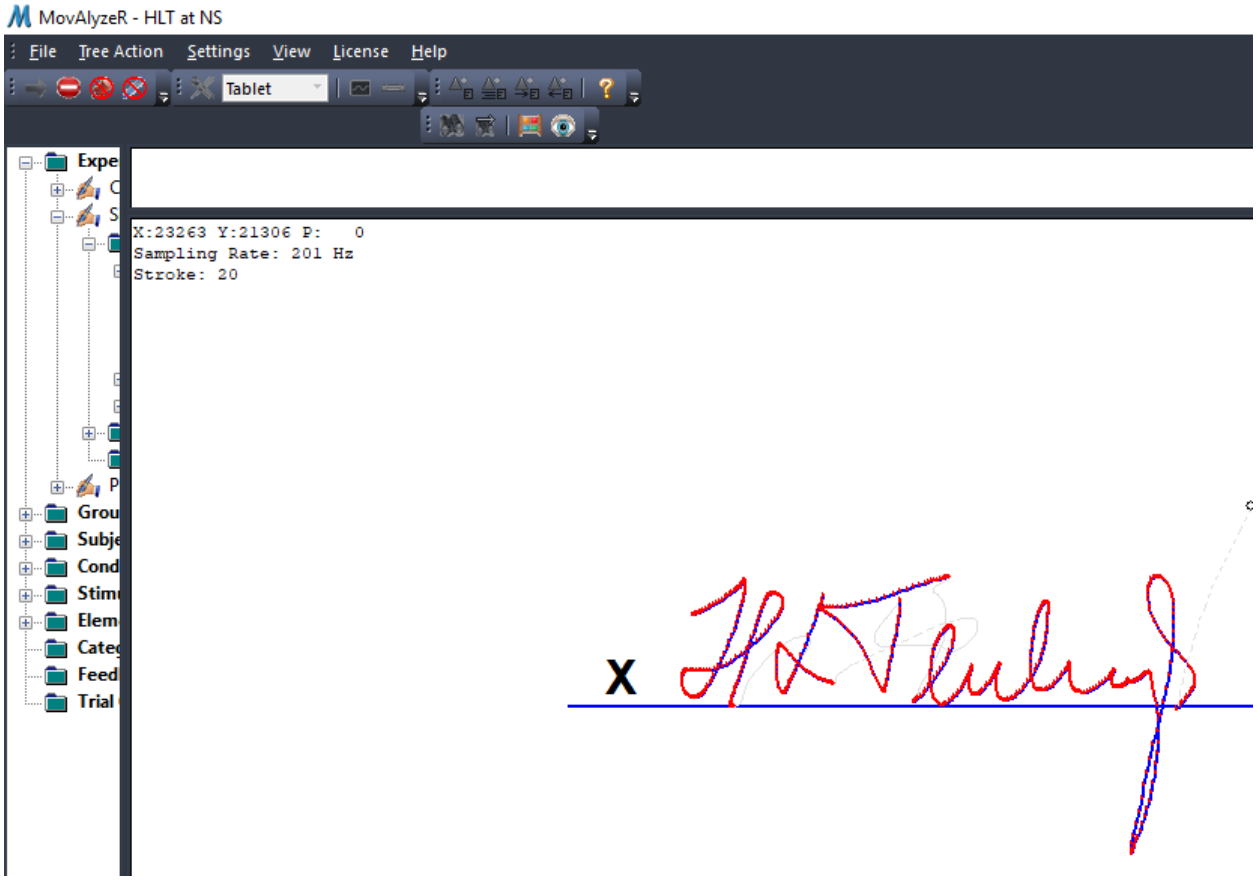


The test starts with an instruction screen.

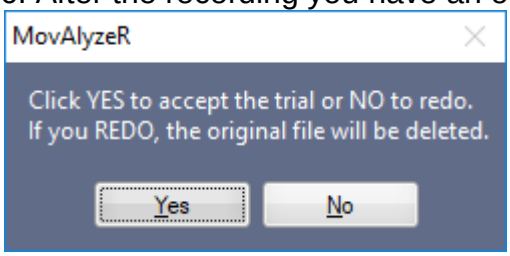


Click Continue.

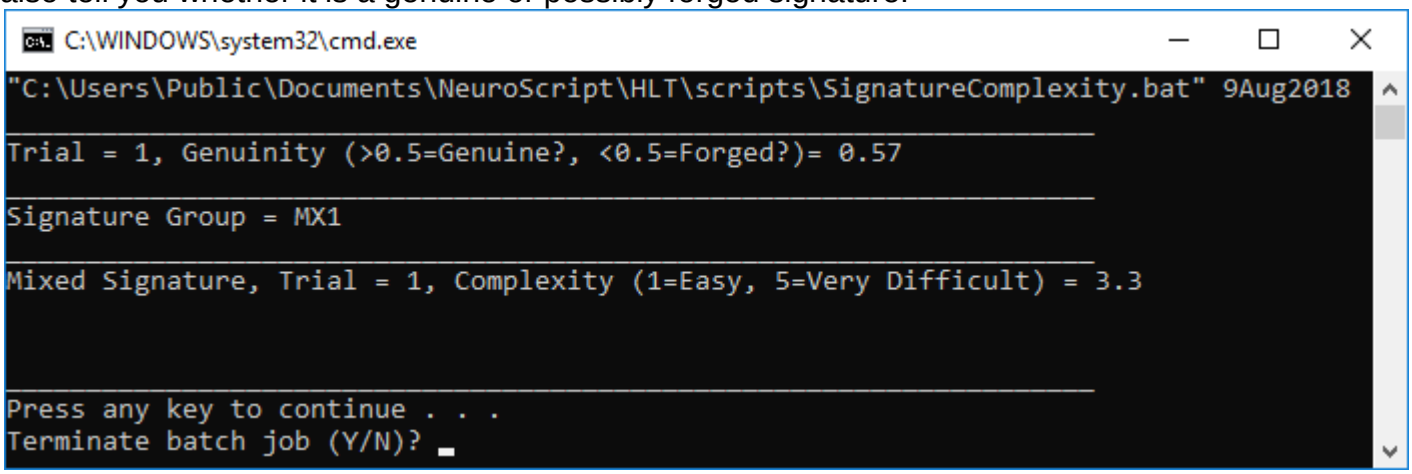
5. Perform a signature (if you have no tablet installed, use your mouse or your finger on a touch screen).



6. After the recording you have an option to accept or redo.

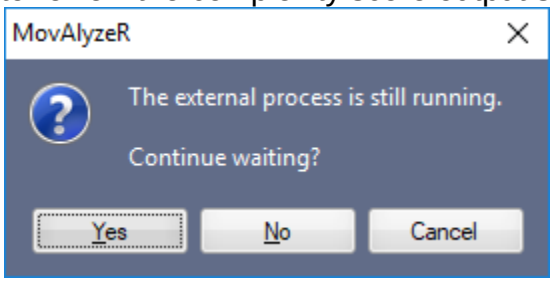


7. Immediately after placing the signature you will see your complexity score. The external app will also tell you whether it is a genuine or possibly forged signature.



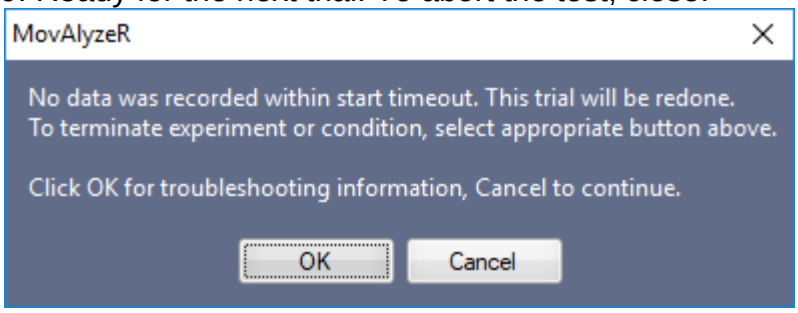
In this screen we calculated complexity for each of the 3 signature styles.

8. You may get an info screen that the external app did not exit immediately because you need time to review the complexity score output screen.

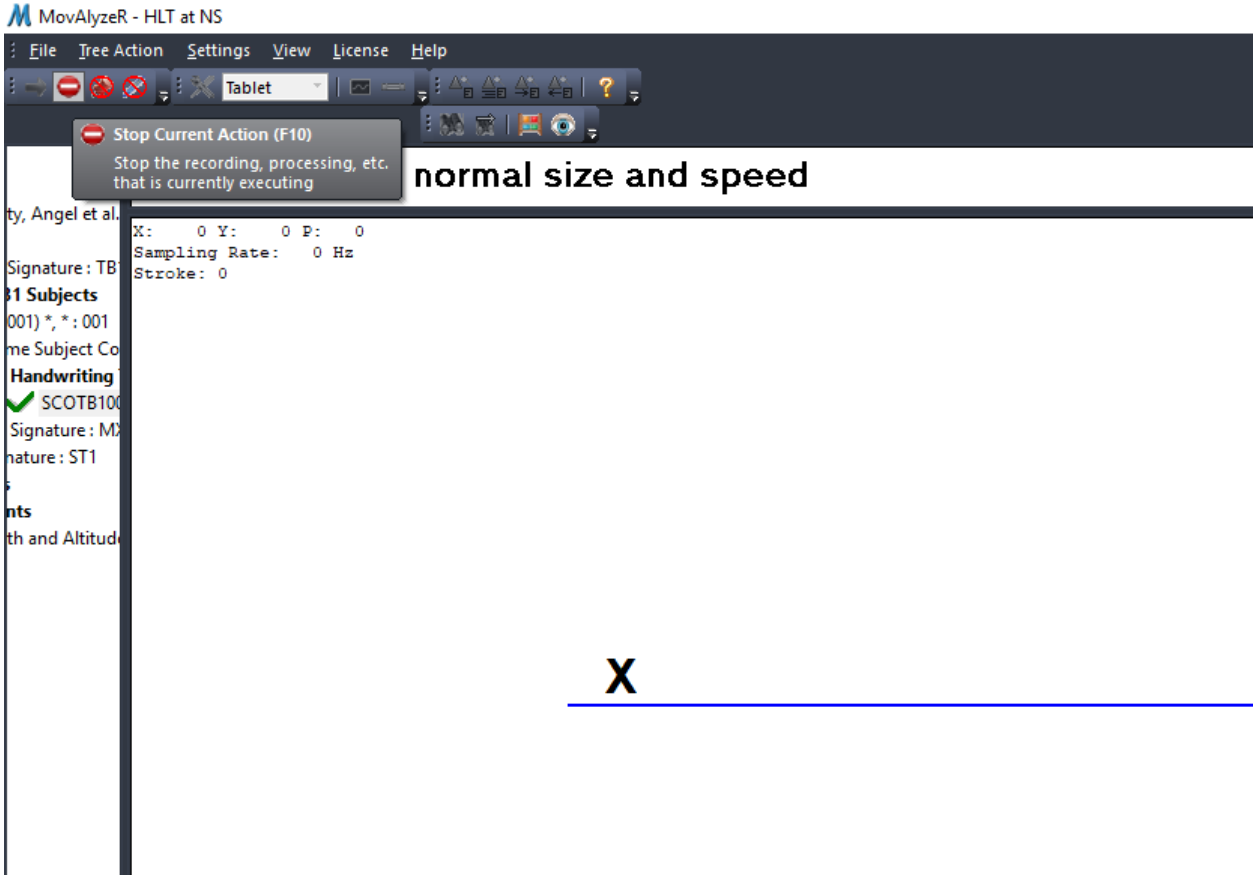


Click No (do not wait). Then you can chart the recorded trial by double clicking on it and view signature and score at the same time.

9. Ready for the next trial. To abort the test, close:



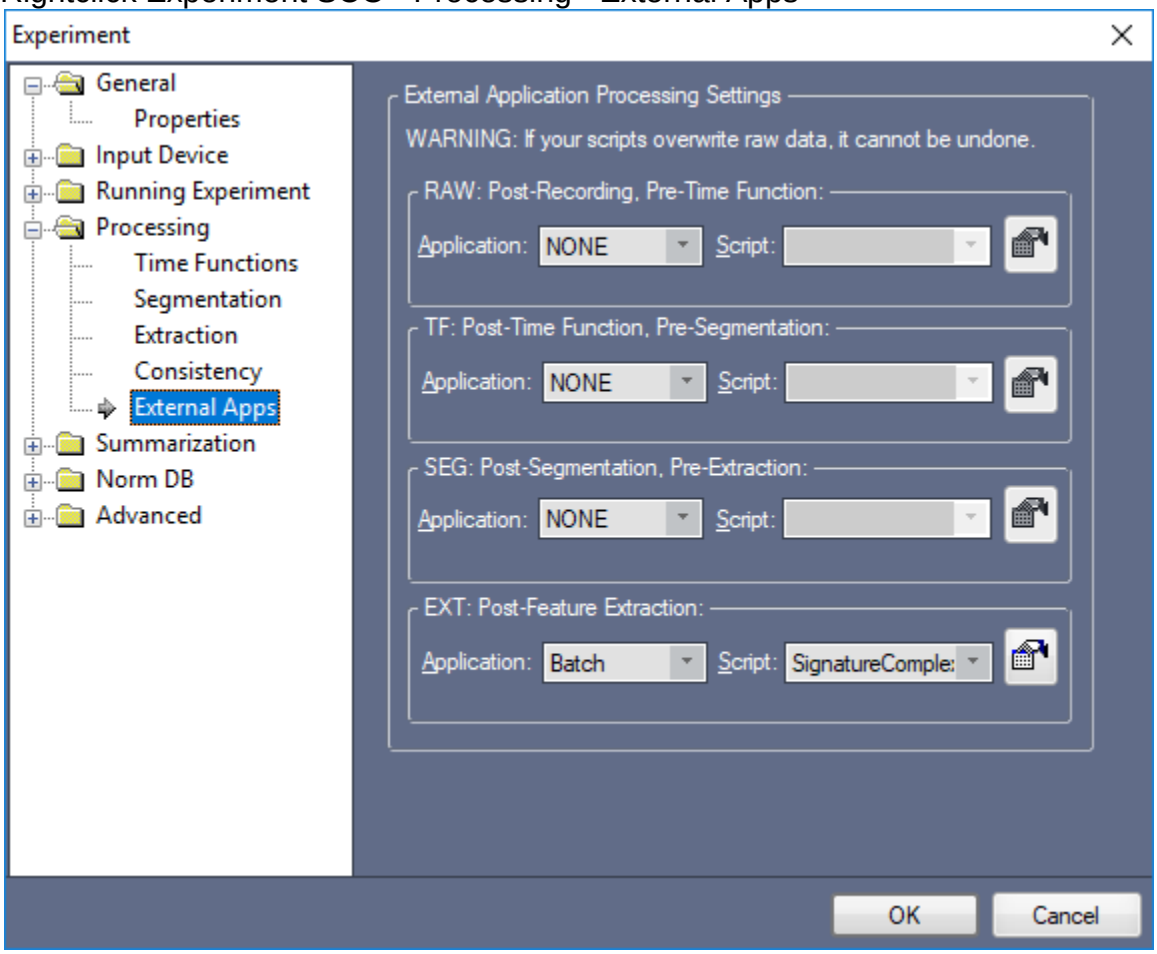
and Click Stop Current Action (Or hit F10)



C. CUSTOMIZATION

1. Customize the External App:

Rightclick Experiment SCO >Processing >External Apps



To add this External App to your existing experiments in your current user, follow the customization instruction and select
o Application=Batch
o Script= SignatureComplexity.bat

Then update Edit Script >Scroll down till: set grouptext=…, set groupmixed=…, set groupstylized=… and insert the proper group names.

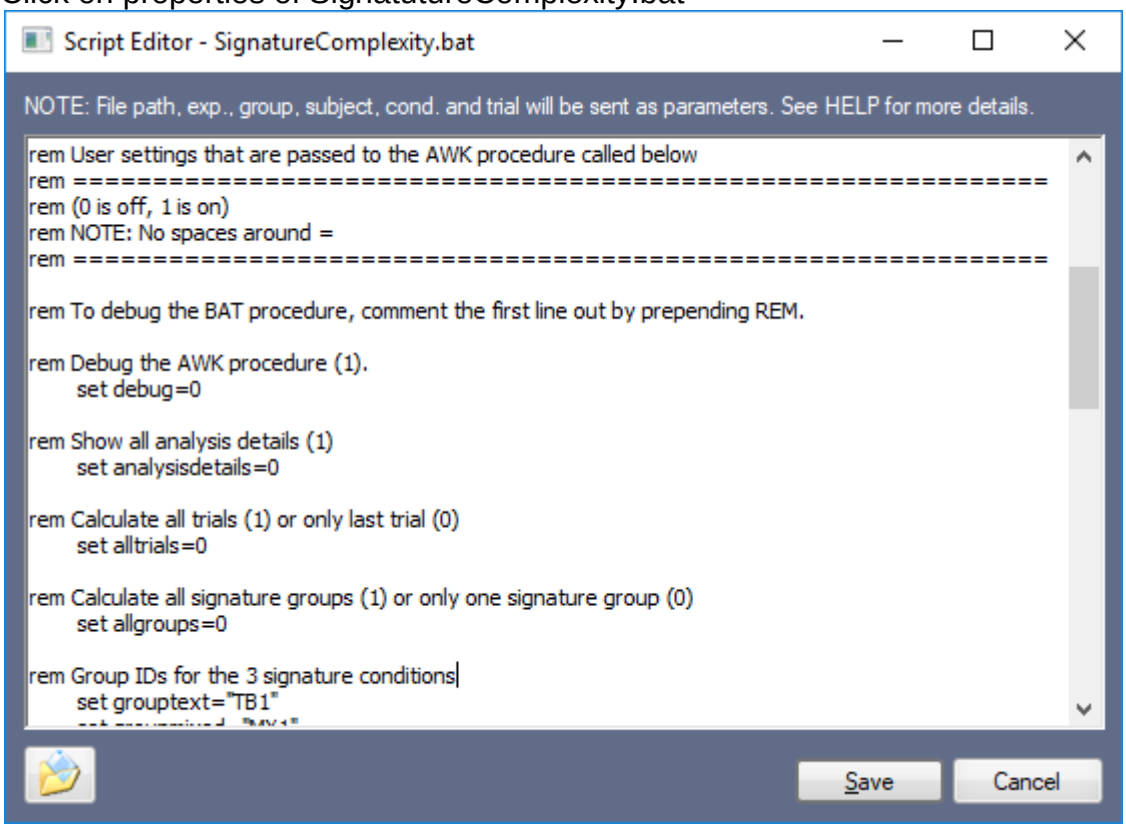
If 3 signature types are under one group, use that Group ID for all 3 Group IDs.

To reprocess existing data: Rightclick a subject or trial >Reprocess Trials

To use this external app under ANOTHER user, say U02, while you imported into your current user, say U01, please, copy the following files from
C:\users\public\documents\neuroscript\U01\Scripts\
to
C:\users\public\documents\neuroscript\U02\Scripts\

```
05/11/2002  11:54 AM           294,912 gawk32.exe ←Needed for 32-bits systems
10/02/2003  08:17 AM           204,800 gawk64.exe ←Needed for 64-bits systems
07/21/2018  11:28 PM            16,878 SignatureComplexity.awk
07/21/2018  11:25 PM             2,485 SignatureComplexity.bat
```

Click on properties of SignatutureComplexity.bat



You can see that: AllGroups=1. So all signature groups will be calculated.
To calculate only one signature group, change it into AllGroups=0.

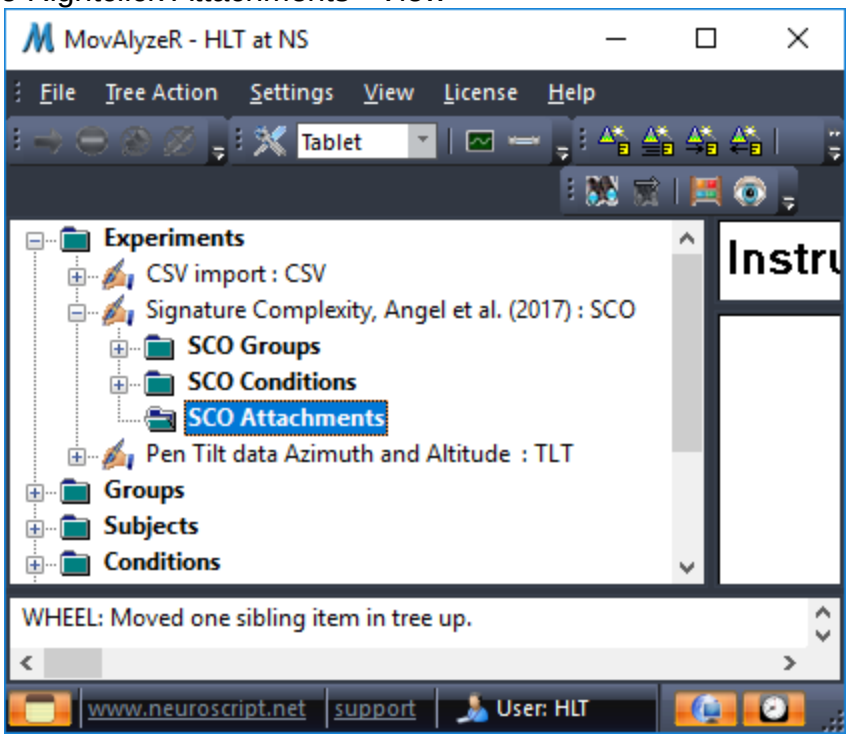
Customization Options:

Debug -- Show a lot of diagnostic output
AnalysisDetails -- Show how the model parameters lead to the end score
AllTrials – Calculate all trials of that condition as opposed to the last one.
AllGroups – Calculate all signature groups (Text, Mixed, Stylized) as opposed to assigned one.
GroupText, GroupMixed, GroupStylized – Set your group IDs for these styles of signatures.

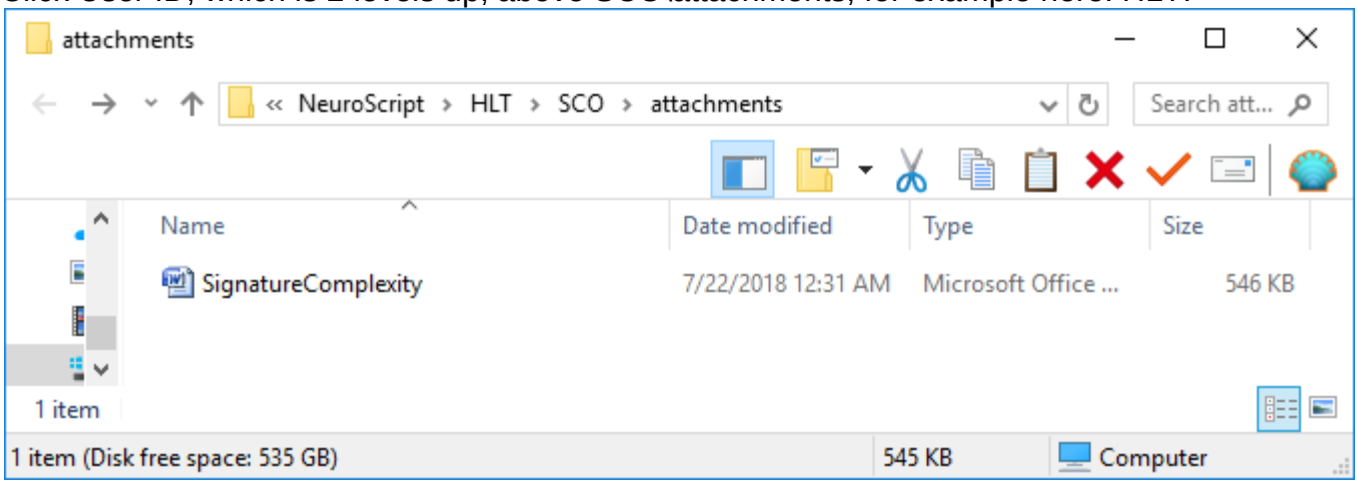
2. Editing SignatureComplexity.awk

AWK is a powerful and quick text and numbers processing programming language which enables to user to do every calculation imaginable very few lines (https://en.wikipedia.org/wiki/AWK).

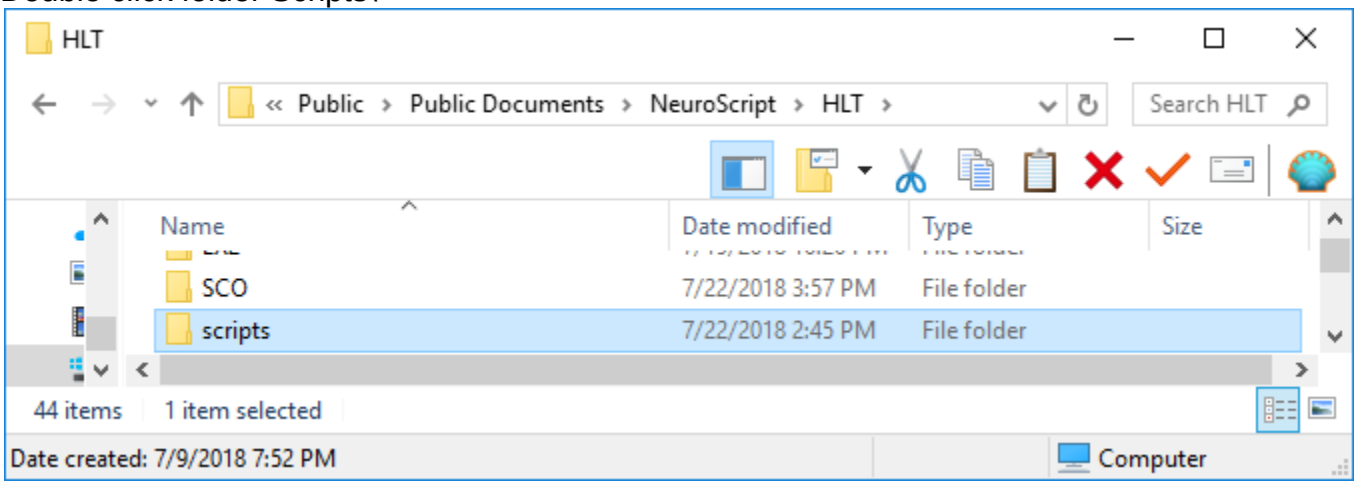
The safest method to open, inspect and edit the .AWK procedure is:
o Expand Experiment SCO
o Rightclick Attachments >View



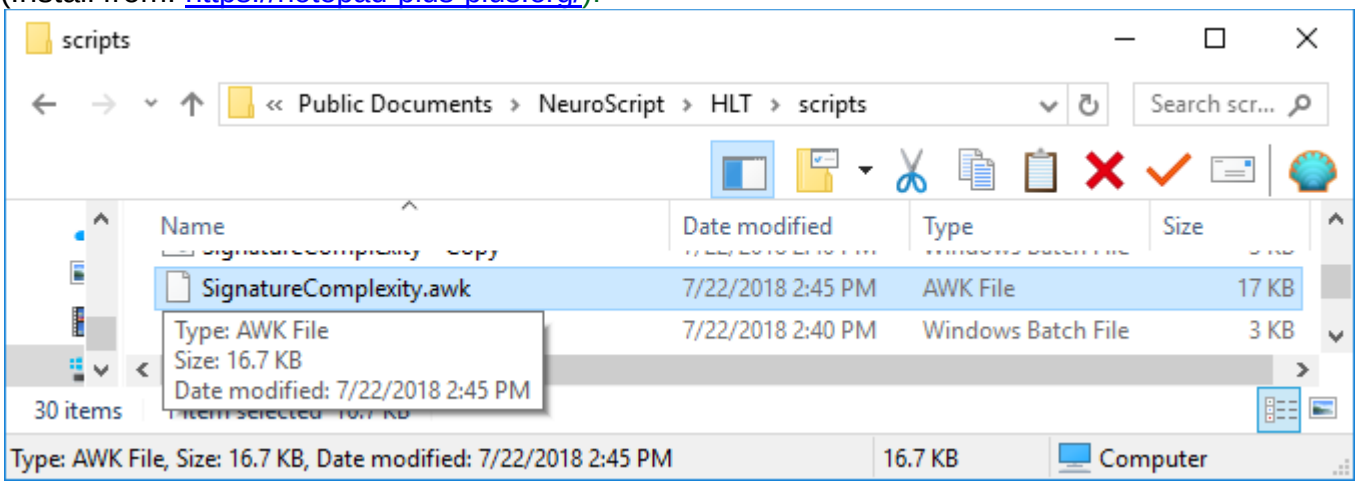
Click User ID, which is 2 levels up, above SCO\attachments, for example here: HLT.



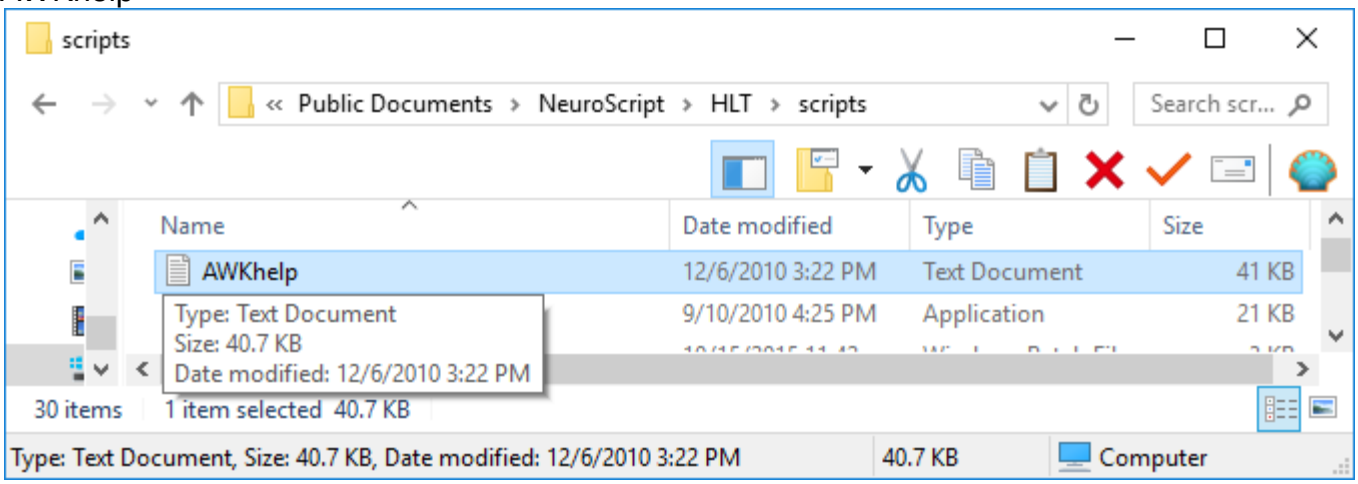
Double click folder Scripts\



Rightclick file SignatureComplexity.awk >Open with >Notepad (Default text editor) or Notepad++ (Install from: https://notepad-plus-plus.org/).



For help on the language of AWK, click:
AWKhelp

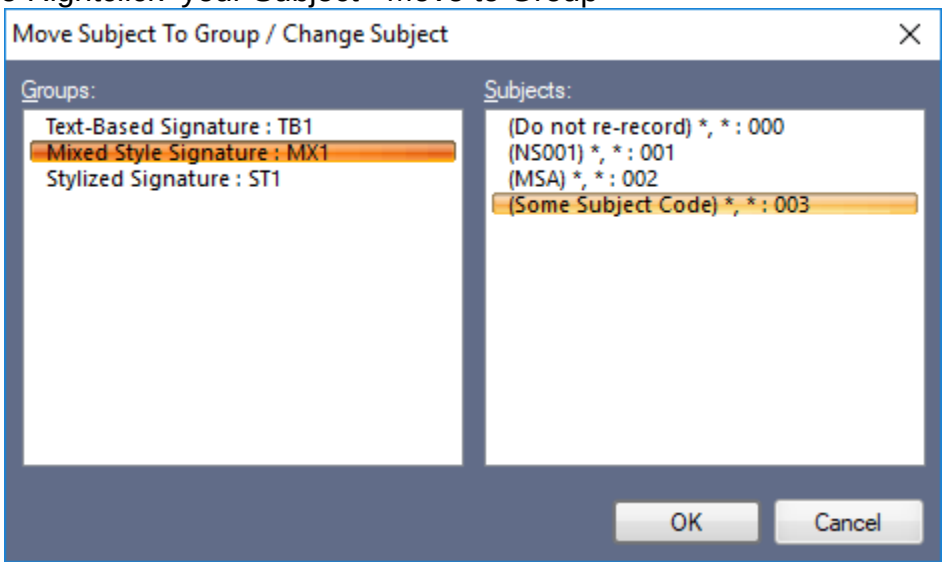


3. Reprocessing

After making changes or just to re-inspect the output results:
Rightclick your subject or single trial>Process >Reprocess
To chart the trial double click on it.

4. Error Correction Moving a Subject to another Subject Group:

o Rightclick your Subject >Move to Group

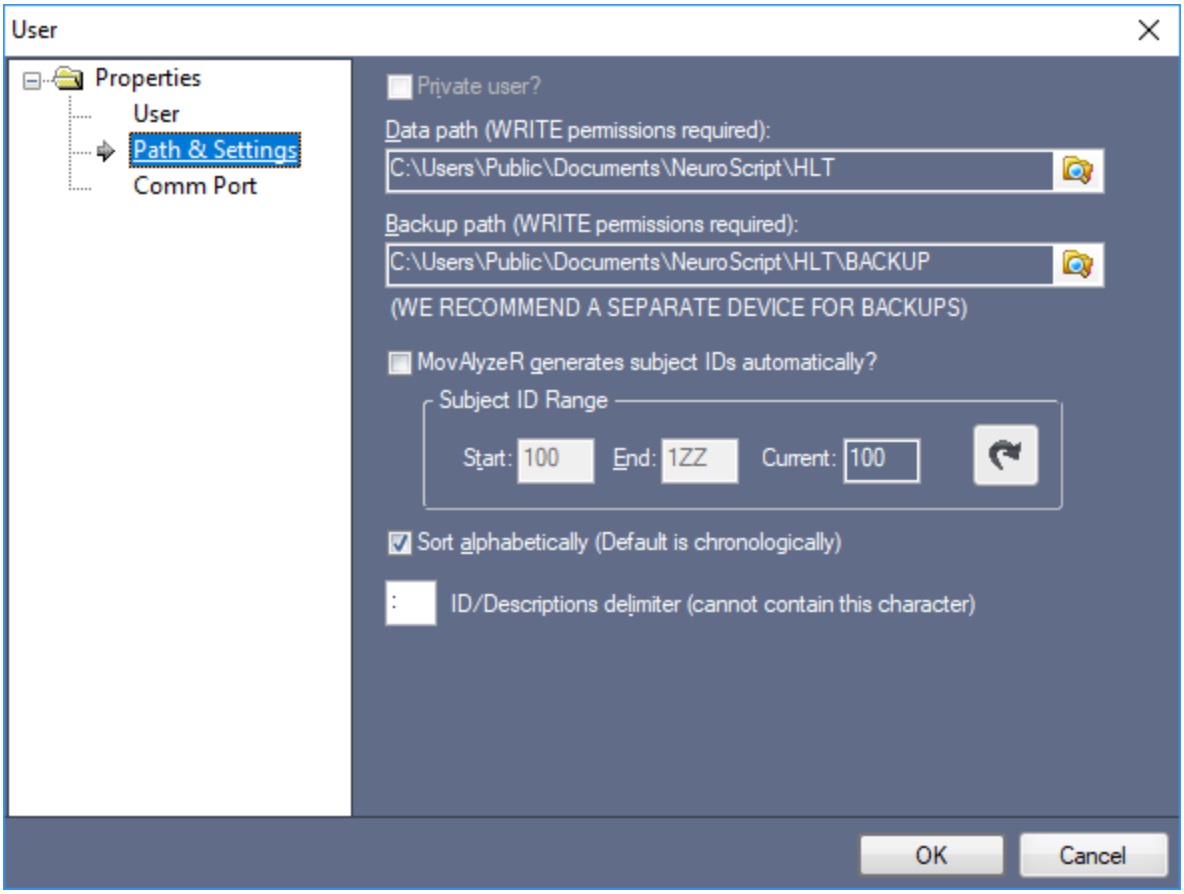


o Select the appropriate Signature Group
o OK

D. Implementation

The External Application estimates the signature complexity. Movalyzer splits the pen movement into a succession of upward and downward segments. Several features are estimated per segment.
Google:
Movalyzer features
(https://neuroscript.net/tutorial/MovAlyzeRFeatures.pdf).

The features used for signature complexity estimation are listed in Scripts\SignatureComplexity.awk which is under the MovAlyzeR user's data path (Settings >User Properties):



The features per segment are averaged within a trial.

Averaged across downward segments (VerticalSize[itrial,isegment] < 0.)

HorizontalSizeDown[itrial]+=HorizontalSize[itrial,isegment]
SlantDown[itrial]+=Slant[itrial,isegment]
DurationDown[itrial]+=Duration[itrial,isegment]
PeakVerticalVelocityDown[itrial]+=PeakVerticalVelocity[itrial,isegment]
PeakVerticalAccelerationDown[itrial]+=PeakVerticalAcceleration[itrial,isegment]

SlantUp[itrial]/=nsegup
StraightnessErrorUp[itrial]/=nsegup
RoadlengthUp[itrial]/=nsegup
PeakVerticalVelocityUp[itrial]/=nsegup
AverageAbsoluteVelocityUp[itrial]/=nsegup

Or averaged across upward segments

SlantUp[itrial]+=Slant[itrial,isegment]
StraightnessErrorUp[itrial]+=StraightnessError[itrial,isegment]
RoadlengthUp[itrial]+=Roadlength[itrial,isegment]
PeakVerticalVelocityUp[itrial]+=PeakVerticalVelocity[itrial,isegment]
AverageAbsoluteVelocityUp[itrial]+=AverageAbsoluteVelocity[itrial,isegment]

SlantUp[itrial]/=nsegup
StraightnessErrorUp[itrial]/=nsegup
RoadlengthUp[itrial]/=nsegup
PeakVerticalVelocityUp[itrial]/=nsegup
AverageAbsoluteVelocityUp[itrial]/=nsegup

The (simplest) complexity score is for text-based signatures:

```
ComplexityTextOffset = +3.71
ComplexityTextNumOfStrokesUpDown = +0.0164
ComplexityTextRoadlengthUp = +1.4511
ComplexityTextDurationDown = -13.371

ComplexityText[itrial]= ComplexityTextOffset +\
                        ComplexityTextNumOfStrokesUpDown * NumOfStrokesUpDown[itrial] +\
                        ComplexityTextRoadlengthUp * RoadlengthUp[itrial] +\
                        ComplexityTextDurationDown * DurationDown[itrial]
```

Similarly for mixed and for stylized signatures.