APEx

User's Guide

Dr. Haug Leuschner

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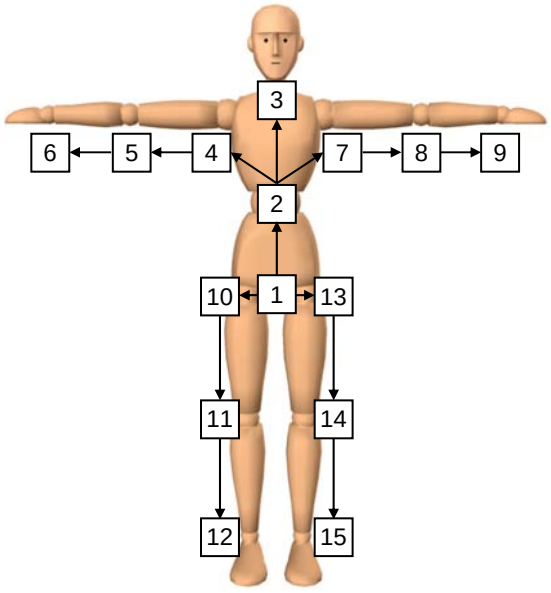
Introduction

To transform motion capture data and 3D animation data according to the nonverbal parameters described in "Microanalysis of nonverbal communication: Development of a nonverbal research method using high-performance 3d character animation" (Leuschner, 2013), the software APEx (*Automatic Parameter Extraction of Nonverbal Parameters*) has been developed. APEx is programmed with around 14,500 lines of code resulting in an executable file of 784 KB. Essentially, APEx reads one or more input files containing data exported from professional 3D animation software, calculates nonverbal parameters according to the formulas developed in the previous chapters, writes the resulting nonverbal data into output files, and outputs statistical data for each input file in a common statistics file. To ensure the best possible ease of use, the user interface of APEx allows high flexibility to specify how APEx should process the input files. The following sections describe in detail how the data in the input files should be formatted, and how they can be obtained, which options the user interface provides and how they can be used, how the output files are formatted and how the data can be read by statistical software packages.



1. Hip joint
2. Chest joint
3. Head joint
4. Right arm joint
5. Right elbow joint
6. Right hand joint
7. Left arm joint
8. Left elbow joint
9. Left hand joint
10. Right leg joint
11. Right knee joint
12. Right foot joint
13. Left leg joint
14. Left knee joint
15. Left foot joint

Figure 1. Generic hierarchical skeleton structure of a human 3D model.

Input Files

Data format. APEx supports plain text files with delimiter-separated values (DSV) as input files. DSV is not a single, well-defined format, but refers generally to any file that consists of data lines (records) divided into fields separated by delimiters where every data line has the same sequence of fields. APEx uses the following specific format.

Format line. The input file begins with the format line labeling the data fields of the data lines. The data field labels can use any alphanumeric character, can have any reasonable length, are separated with a delimiter, and must not enclose by quotation marks. The first data field is the time field and the label of the time field must be specified in the dedicated input box labeled ‘Time Field’ of the user interface (see tab page ‘Input Files’). The second data field is the frame number and can be labeled in any way. The following data field labels designate the translation and rotation values of the 3D model joints and markers. These data field labels consist of a data field name and a data field type separated by a colon. The data field name is the name of the corresponding joint or marker. The data field type can be ‘Tx’, Ty’, Tz’, ‘Rx’, Ry’, or ‘Rz’: T denotes translation, R indicates rotation, and the letters x, y, and z specify the dimension. If a sequence of consecutive data field labels belongs to the same joint or marker, only the first label of the sequence must have a name; the other labels can omit a name and comprise only the data field type. Several comment lines can be inserted before the format line. The data lines immediately follow the format line.

Data lines. Each time point of a 3D animated time sequence has an own data line in the input file. Each data line begins with a time value and a frame number; the following data fields consist of the translation and rotation values of the 3D model joints and markers for a single time point. The first field of the data line identifies the time point of the time sequence. With regard to each data line in an input file, the time value should have the same distance to the time value of the previous data line. All data fields are separated by a delimiter.

Delimiter. The delimiter used to separate data field labels in the format line or data field values in a data line can be any character. Regardless of the file extension, APEx uses the first character immediately following the time field of the format line as delimiter. Therefore, most delimiter-separated value file formats, such as comma separated values (CSV) or tab separated values (TSV), are supported.

Values. The input files consist of global translation and rotation values of the joints and markers of the hierarchical skeleton structure of a human 3D model in professional 3D animation software (see *Figure 1*, p. 1). *Global values* means that the translation and rotation values of joints are referenced by the global scene origin of the 3D world. In contrast, local values of a joint are referenced to the corresponding parent joint hierarchically superior to it. APEx is designed to process global values; if local values are used, the nonverbal data that APEx calculates and outputs will be incorrect.

Decimal point. A dot must be used as decimal point.

```
1  Exported global values of scene 'USA No. 3: Chief & Employee'
2  Time [sec];Frame;Hips:Tx;Ty;Tz;Rx;Ry;Rz;Chest:Tx;Ty;Tz;Rx;Ry;Rz;Head:Tx;Ty;Tz;Rx;Ry;Rz;
3  0;1;-2.257270336;21.98801804;4.980587006;-173.3709717;72.34246063;-172.6352844;-2.01799
4  0.01;2;-2.257270336;21.98801804;4.980587006;-173.3709717;72.34246063;-172.6352844;-2.01
5  0.02;3;-2.260074615;21.9872818;4.982691765;-173.515152;72.25010681;-172.7256622;-2.0239
6  0.03;4;-2.260074615;21.9872818;4.982691765;-173.515152;72.25010681;-172.7256622;-2.0239
7  0.04;5;-2.265665531;21.98579216;4.986915588;-173.8012085;72.06500244;-172.9040375;-2.03
8  0.05;6;-2.267072916;21.98533058;4.988647461;-173.9111328;71.99916077;-172.9831696;-2.03
9  0.06;7;-2.267025709;21.98513412;4.990031719;-173.9806061;71.9641037;-173.0478668;-2.039
10 0.07;8;-2.265933514;21.9851284;4.991160393;-174.0215454;71.95108795;-173.1026459;-2.037
11 0.08;9;-2.264173031;21.98531532;4.992023468;-174.0555878;71.94772339;-173.1595154;-2.03
12 0.09;10;-2.262120962;21.98569489;4.992609978;-174.1042633;71.94156647;-173.2303467;-2.0
13 0.1;11;-2.259544849;21.98632431;4.992821693;-174.1746368;71.93434143;-173.3225708;-2.02
14 0.11;12;-2.256354809;21.98718071;4.992695808;-174.2548676;71.93097687;-173.4284973;-2.0
```

Figure 2. Example of an input file with comment line, format line, and data lines.

Example. *Figure 2* shows the first data fields and first data lines of an input data file. The first line is a comment line, which will be ignored by APEx. The second line is the format line beginning with the time field label ‘Time [sec]’, the frame no. label ‘Frame’, and the data field labels for the global values of the hips, the chest, and the head. Then follow some data lines, numbered from one to twelve, with a frame rate of 10 fps.

Export from 3D animation software. Professional 3D animation software, such as MotionBuilder, has generally no possibility of exporting global data in a DSV format suitable for APEx. That 3D software uses proprietary binary data formats, which are additionally subject of changes between different versions. Because those proprietary data files cannot be used as input files, a script has been developed to export the 3D global data to DSV files.

Installation of the Script 'Export Global Data'. Appendix C (p. 18) contains a python script written for MotionBuilder 2012 and subsequent versions. If this script is placed in a text file with the name 'ExportGlobalData.py' in the subfolder 'bin\config\PythonStartup' of MotionBuilder's installation folder, a menu item 'Export Global Data' will be available in the 'Python Tools' menu of MotionBuilder. If you don't have MotionBuilder, you can install the free student version, import your motion capture data into MotionBuilder and use the script to export the global translation and rotation data as required.

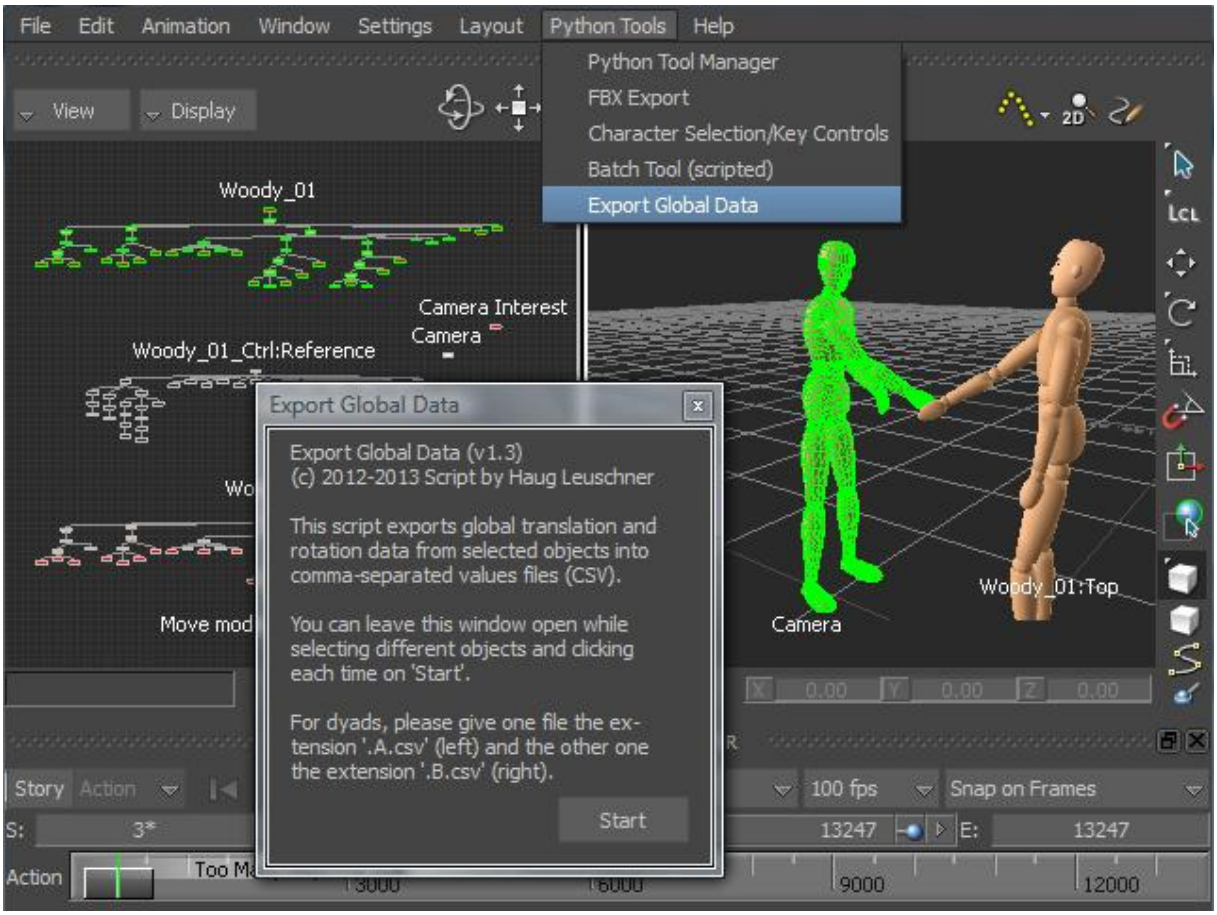


Figure 3. Menu item 'Export Global Data' in MotionBuilder's 'Python Tools' menu.

Usage of the Script 'Export Global Data'. (1) Start MotionBuilder 2012 (or higher) and open a scene with animated 3D models. (2) As shown in *Figure 3*, select the joints and markers of a human 3D model. If camera parameters are of interest, mark additionally a camera and a camera interest. If intending to use the *static SRL system*, you may mark additionally a chair or another object (for more details, please refer to Appendix B on p. 17). (3) Select the menu item 'Export Global Data' in the 'Python Tools' menu of MotionBuilder. (4) A tools window with the title 'Export Global Data' and a button 'Start' appear. Click on the 'Start' button. (5) A file dialog window appears which proposes to store the exported data in a file in the user's home directory with the name of the scene and the extension '.csv'. Please ensure that the extension of the data file for one person is '.L.csv' (left person) or '.A.csv' (other cases) and for the other it is '.R.csv' (right person) or '.B.csv' (other cases). Then hit on 'Save'. (6) Repeat Steps (1) to (5) for the other person in the dyad.

User Interface

The user interface of APEx consists of three tab pages: the ‘Input Files’ tab page, the ‘Data Fields’ tab page, and the ‘Parameters’ tab page. All tab pages allow specific options to be set for how APEx should process the data of the input files. This includes the option to modify and enhance the default set of nonverbal parameters by using a base set of freely combinable calculation functions. After all options are chosen and the calculation is started by clicking on ‘Calculate’, APEx processes all specified input files at once and, if necessary, writes error messages in the output files and points to them at the end of the job.

Tab page ‘Input Files’. As shown in *Figure 4*, the input files are specified in the tab page ‘Input Files’. In the center of the window, the *input file list* displays the input files and the options chosen for them. On the right side of the *input file list*, a set of buttons and input fields allow the user to modify the *input file list* and to open the files with an external editor.

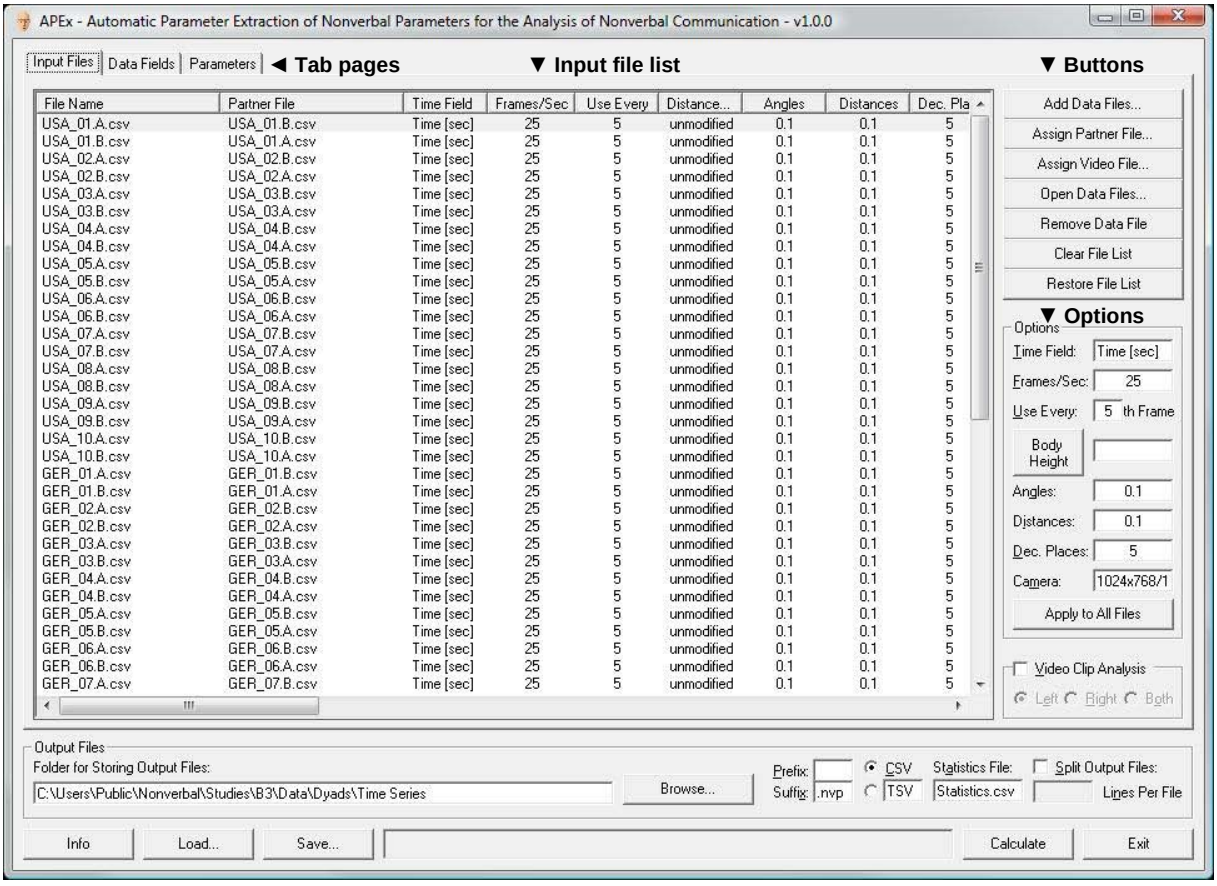


Figure 4. The tab page ‘Input files‘ of APEx’s user interface.

Options. Input file options are available for each input file separately. They are shown in the *input file list* and can be preset before adding one or multiple data files or can be modified after selecting a data file in the *input file list* by changing the values in the input fields on the right side of the window. The following options are available for each input file.

Time Field. This option identifies the name of the first data field in the format line of the input file. If the entered string does not match the first data field name of the format line, APEx will show an error message that it could not find the format line.

Frames/Sec. This option shows the frame rate as 'frames per second' (fps) . The fps value is calculated from the first two data lines while an input file is being added, but can be modified afterwards, if desired. The fps values of the two input files of a dyad must match. Otherwise, APEx shows a message that the files cannot be assigned to each other.

Use Every. This option offers the possibility to adjust the magnitude of the calculated nonverbal parameter values. Very small periods between two frames can reduce the calculated values of dynamic nonverbal parameters to virtually nothing. With this option, it is possible to enhance the period between two time points: 'Use Every 2nd Frame' will omit each 2nd frame.

Body Height. This option specifies the height of the real actor to recalculate all distance measures (*Symmetry*, *Expansion*, *Distance*, *Openness*, *Dyadic Proxemics*, *Translational Complexity*, and *Translational Magnitude*) of the 3D model into the metric of the real person. Entering no value will result in unmodified distance measures. By pressing this button, all distance measures can be alternatively calculated as the percentage of the 3D model body height or its limb length ensuring comparability between differently sized models.

Angles and Distances. For statistical nonverbal parameters, a threshold value is used to filter invisible micro movements. This applies to distances as well as angles. All *Complexity*, *Magnitude*, *Activation*, and *Time Spent in Motion parameters* use these threshold values (see Table 2, p. 22); only values greater than the threshold value are taken into account. The recommended default threshold value is 0.25 for angles and 0.1 for distances.

Decimal Places. This option specifies the number of decimal places in the output files. APEx calculates internally to 15 decimal places, but for most purposes, it is sufficient to use between two and five decimal places for the output.

Camera. This option lists the camera settings used for *camera-related parameters* (see Table 2, p. 22). The camera settings comprise the values for *width*, *height*, *near plane*, *far plane*, and *field of view*, which can be read from the tab page 'Camera Settings' of the navigator window in MotionBuilder, as shown in *Figure 5*. The values are entered in the input field 'Camera' in the format: '*width* x *height* / *near plan* / *far plane* / *field of view*'. Regarding *Figure 5*, the camera settings should be entered without spaces as '1024x768/10/4000/40'.

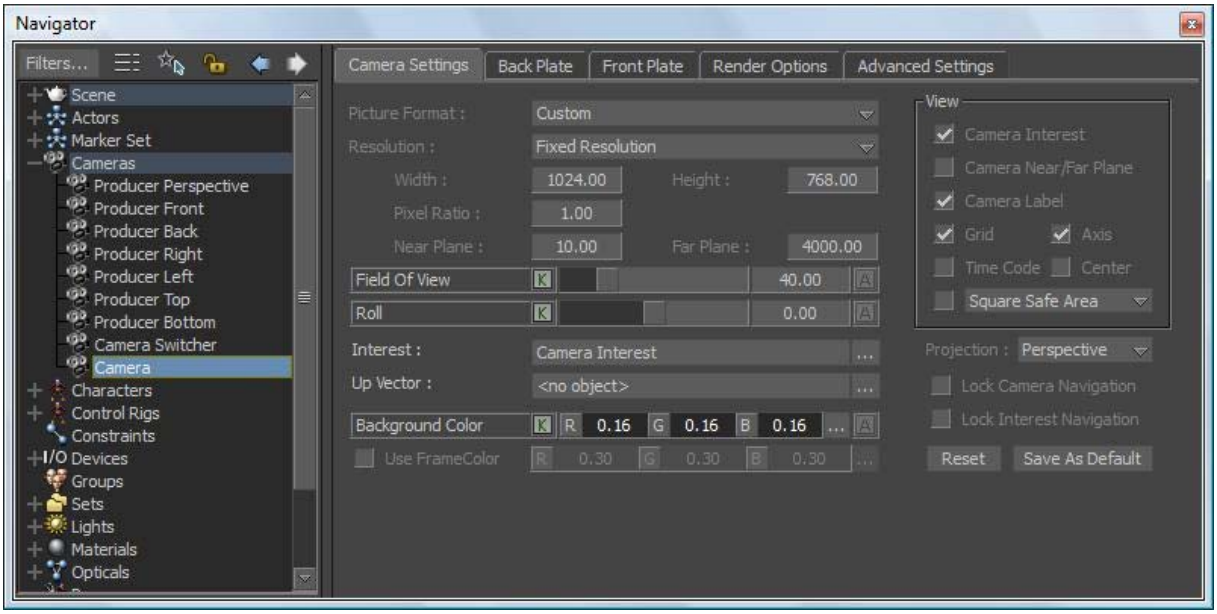


Figure 5. The tab page 'Camera Settings' in the navigator window of MotionBuilder.

Video Clip Analysis. The parameter *Pixel Difference* (see Table 2, p. 22) counts the number of changed pixels between two frames of a video file. By switching the option 'Video Clip Analysis' on, a file dialog appears to select a video file for a input file; only AVI files are supported. The option 'Left Side' is automatically assigned to input files with the extension '.L.*' or '.A.*', and the option 'Right Side' to input files with the extension '.R. *' or '.B. *'. In all other cases, the user can choose one of the options 'Left', 'Right', or 'Both' sides.

Buttons. With the buttons of the tab page ‘Input Files’ the content of the *input file list* can be modified by adding and removing input files, or assigning partner and video files. Holding the ‘Ctrl’ key shows the keys associated with the buttons for keyboard control.

Add Data Files. This button opens a file dialog window to add one or more input files to the *input file list*. All selected input files are inspected for a valid format line. If two input file names have the same name with the extensions ‘.L.*’ and ‘.R.*’ (or ‘.A.*’ and ‘.B.*’), they are automatically assigned to each other as partner files. It is necessary that all input files have the same data field names, and that the partner files of a dyad have the same frame rate.

Assign Partner File. This button allows the user to assign a partner file to a selected input file without the need to have same file names with the extensions ‘.L./.R.’ or ‘.A./.B.’.

Assign AVI File. This button offers the same functionality as the option ‘*Video Clip Analysis*’, but allows the user to change the assignment of a video file.

Open Data Files. This button opens a dialog enabling the user to open the input data file, the output data file, and/or the statistics file. APEx transfers the file names to the operating system that launches the programs associated with the extensions of the chosen files.

Remove Data File. This button removes the selected input file.

Clear File List. This button removes all input files from the *input file list*.

Restore File List. This restores the *input file list* loaded automatically at program start.

Apply to All Files. This allows the user to change the options for all files at once.

Tab page ‘Data Fields’. The nonverbal parameters are implemented with a set of base functions that require particular input variables. Although the names of the predefined default input variables are fixed (e.g., ‘Head’, ‘Chest’, or ‘Hips’, as listed in Table 1, p. 21), the data field names of the input file are exported from a human 3D model and hence are arbitrary and variable. With the tab page ‘Data Fields’, the variable names of the input data fields can be mapped to the fixed names of the input variables. Moreover, the user can specify a set of user-defined input variables for other 3D model joints (e.g., fingers or eyes).

Default input variables. As shown in *Figure 6*, the joints of the generic human 3D model are underlined; the non-underlined input variables are markers (see *Figure 1*, p. 1, and Table 1, p. 21). Every data field of the input files can be assigned to an input variable by the user choosing its name from the appropriate selection field. If a calculation function relies on the data of an input variable that has not been assigned to a data field, APEx writes error messages into the output files, with the exception of 'Base'. If 'Base' is not specified, the global scene origin of the 3D world is used as 'Base'.

User-defined input variables. The tab page 'Data Fields' offers the user the possibility to specify up to 50 additional input variables by selecting a data field from a selection field within the area of user-defined input variables and uniquely naming the new input variable. *Figure 6* shows two user-defined input variables for the ankles of a human 3D model. A user-defined variable can be removed by deselecting its data field name, i.e., choosing the empty item of the selection field, and can be deleted by removing all characters in its name field.

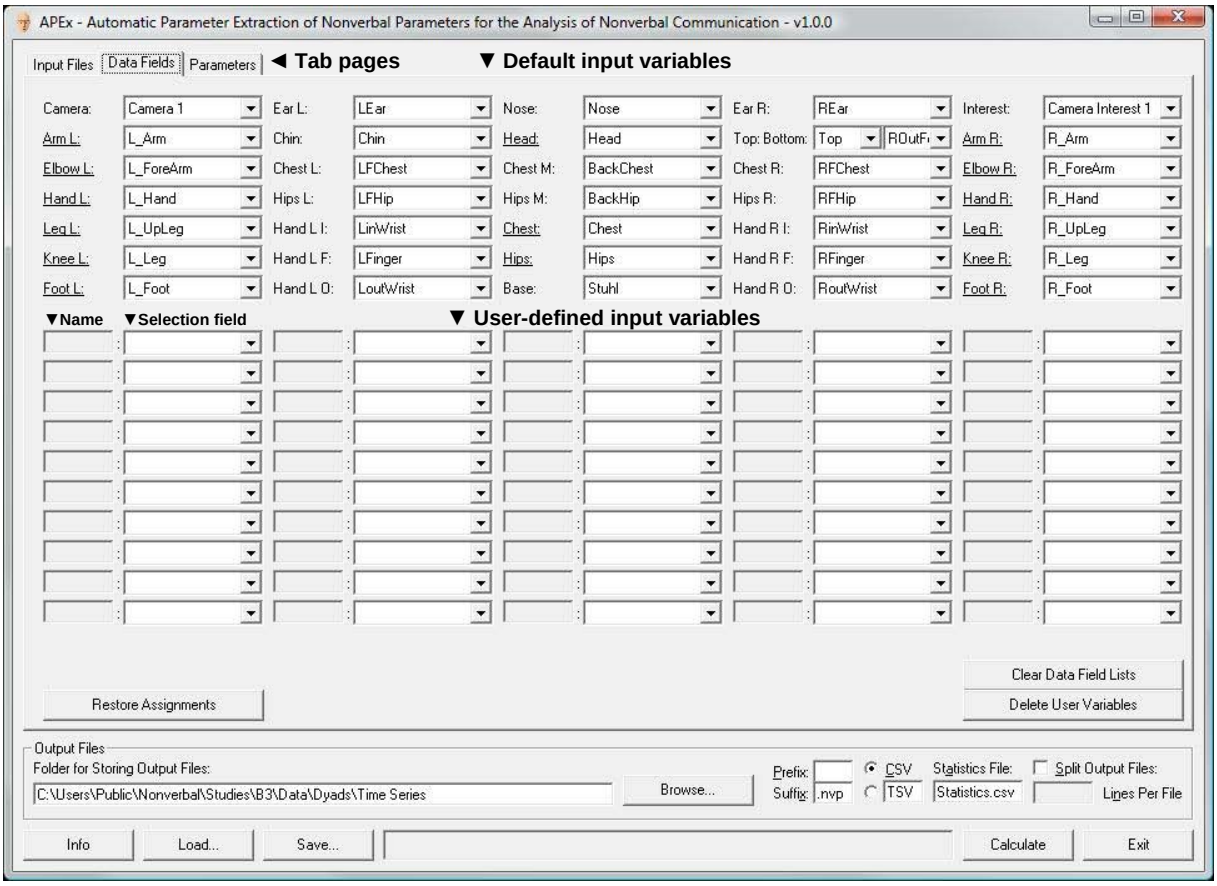


Figure 6. The tab page 'Data fields' of APEx's user interface.

Buttons. The selection fields of the tab page 'Data Fields' collect the data field names of all input files ever read. Before a new project with new input files is set up, the selection fields should be emptied. Furthermore, all user-defined variables can be deleted at once by pressing the appropriate button. Holding the 'Ctrl' key means the keys associated with the buttons are displayed and thus can be used if keyboard control is desired.

Clear Data Field Lists. Use this button to empty all selection fields.

Delete User Variables. Use this button to delete all user-defined variables.

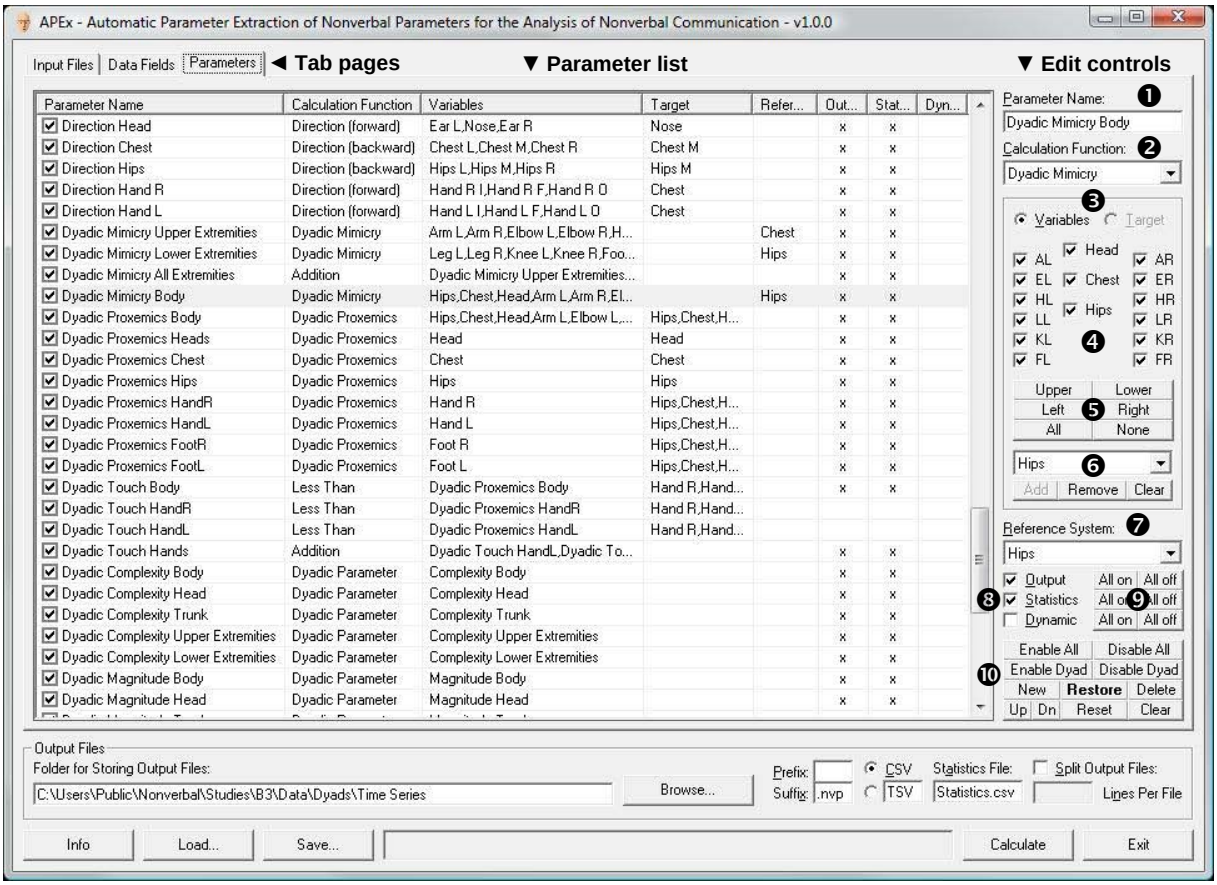


Figure 7. The tab page 'Parameters' of APEx's user interface.

Tab page 'Parameters'. This parameter list defines how APEx processes the data of the input variables that are mapped to the data fields of the input files using the tab 'Data Fields'. By default, this parameter list includes a set of 150 predefined parameters that can be modified and extended. All nonverbal parameters use the calculation functions described in "Microanalysis of nonverbal communication" (Leuschner, 2013).

Parameter list and edit controls. As shown in *Figure 7*, each line of the parameter list represents a nonverbal parameter definition comprising eight items, which can be modified by selecting the definition line in the parameter list and using the edit controls on the right side of the tab page 'Parameters'. Any changes made with the edit controls have an immediate effect on the definition of the selected nonverbal parameter.

Parameter Name. The 'Parameter Name' names the data fields in the output file and can be used as input variable by subsequent nonverbal parameters in the parameter list. The parameter name must be uniquely specified not only for other nonverbal parameters, but also for the input variables defined on the tab page 'Data Fields' (see *Figure 7*, symbol ❶).

Calculation function. This identifies the function used to calculate a nonverbal parameter. The calculation function outputs one or more values for each nonverbal parameter and uses the parameter name to name the data fields in the output files; e.g., the nonverbal parameter 'Static SRL Hips' outputs the values 'Static SRL Hips Sagittal', 'Static SRL Hips Rotational', and 'Static SRL Hips Lateral' (see ❷).

Variables and Targets. 'Variables' and 'Target' list the input variables used by calculation functions. Some calculation functions need two different sets of input variables; the second one can be understood as the 'target' of a nonverbal behavior. Input variables can be either data fields specified on the tab page 'Data Fields' or nonverbal parameters defined previously in the parameter list. If users want to change an input variable specified for a nonverbal parameter, they select the appropriate definition line and pick either 'Variables' or 'Target' (see ❸). Then they choose the desired input variable from the selection field for input variables (see ❻). If only one input variable can be specified for a calculation function, the selection takes immediate effect. If more than one input variable can be specified, the button 'Add' below the selection field can be used to add the chosen input variable to the variable list, and the button 'Remove' removes the selected input variable from the variable list. To add and remove the joints of a human 3D model with a single click, check boxes for single

joints (see ❹) and buttons for the joints of extremities or body sides (see ❺) can be used. The button ‘Clear’ removes all input variables from a nonverbal parameter definition (see ❻).

Reference system. This selection specifies the frame of reference needed by the calculation functions *Static SRL*, *Local Dynamic SRL*, *Symmetry*, *Dyadic Mimicry*, and *Coordinate Transformation* (see ❼).

Output. This option specifies whether result values of a calculation function should be written to the output file (see ❽). On the right side, the buttons ‘All on’ and ‘All off’ can be used to enable or disable this option for all nonverbal parameters (see ❾).

Statistics. This option specifies whether APEx should calculate statistics on the result values and output them to the statistics file (see ❽). On the right side, the buttons ‘All on’ and ‘All off’ can be used to enable or disable this option for all nonverbal parameters (see ❾).

Dynamic. This option specifies whether differences between result values of two consecutive time points should be calculated (see ❽). This option is not available for dynamic calculation functions and works only with the ‘Output’ or the ‘Statistics’ option, i.e., the differences of result values will only appear in the output file if the option ‘Output’ is chosen, and in the statistics file if the option ‘Statistics’ is chosen. On the right side, the buttons ‘All on’ and ‘All off’ can be used to enable or disable this option for all parameters (see ❾).

Enable/Disable All/Dyad. The button ‘Enable All’ sets the check marks of all nonverbal parameters and hence enables all definitions of nonverbal parameters, and the button ‘Disable All’ removes the check marks of all nonverbal parameters and disables them. The button ‘Enable Dyad’ sets the check marks of all parameters involved in dyadic interactions, and the button ‘Disable Dyad’ removes the check marks of all dyadic parameters (see ❿).

New. The button ‘New’ allows the user to define a new nonverbal parameter. When this button is clicked, a new entry appears at the end of the parameter list. Before the new nonverbal parameter can be enabled by setting its check mark, a unique name must be given, a calculation function chosen and the input variables specified (see ❿).

Del. This button deletes the selected nonverbal parameter definition (see ❿).

Up/Down. The order of nonverbal parameter definitions in the parameter list matters, because nonverbal parameters serving as input variables for other nonverbal parameters must be defined before them. With the buttons ‘Up’ and ‘Down’ each nonverbal parameter can be moved up and down in the parameter list to ensure the correct order of calculations (see ❿).

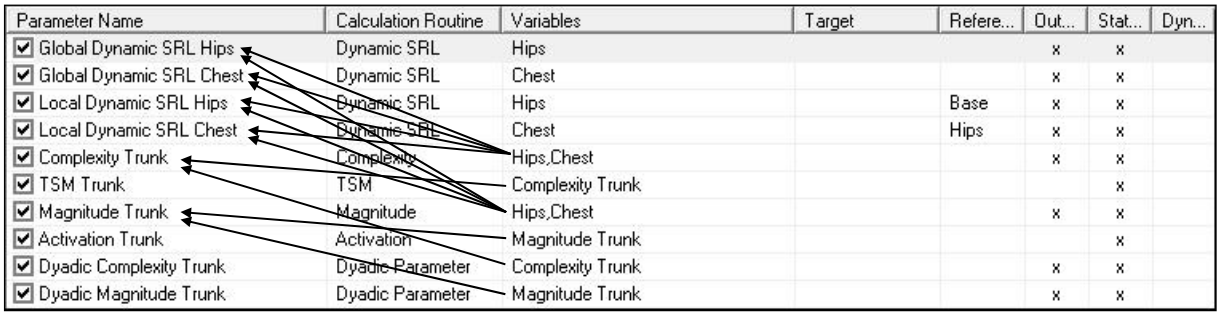
Restore/Reset/Clear. The button ‘Restore’ restores the parameter list to the nonverbal parameter definitions loaded at program start. The button ‘Reset’ generates the default parameter list of APEx. The button ‘Clear’ removes all parameter definitions from the list (see ❿).

Saving, restoring, resetting. Every modification to the parameter list takes immediate effect by overwriting the existing nonverbal parameter definitions. The following strategies are recommended to deal with user mistakes: (1) the user can read the meanings of all buttons by holding the mouse pointer above them for more than one second; (2) the user can restore the set of nonverbal parameters loaded at program start by clicking on 'Restore'; (3) the user can load the default set of nonverbal parameters by clicking on 'Reset'. Furthermore, the following procedures are available to save or drop modifications to the parameter list: (1) the user can save changes to all settings including modifications to the parameter list by leaving APEx and answering 'Yes' to the question about saving the settings; (2) the user can keep the settings loaded at program start including nonverbal parameter definitions by leaving APEx and answering 'No' to the question about saving the settings. Most importantly, the following file operations are available for handling several sets of nonverbal parameter definitions: (1) the user can save all settings together with their own set of nonverbal parameter definitions in a file by clicking on 'Save'; (2) the user can load previously saved settings together with their own set of nonverbal parameter definitions by clicking on 'Load'.

Calculation functions. Table 1 and Table 2 (see Appendix D, p. 21-25) present detailed information about the implemented set of calculation functions and their input and output variables. In addition, two examples of user-defined nonverbal parameters are given.

Number of variables of the default set. The default set of 150 nonverbal parameters calculates 380 different output variables for each input line and 1,504 different statistical variables for each input file. Enabling the options ‘Output’ and ‘Statistics’ for all nonverbal parameters of the default set, APEx will compute 485 different output variables and 1,922 different statistical variables. Additionally, by using the option ‘Dynamics’ for all nonverbal parameters, APEx will calculate 830 output variables and 3,255 statistical variables.

Dependencies between Parameters. A nonverbal parameter using another nonverbal parameter as input or target variable requires that the used variable should have been previously defined in the list and checked as active. The complexity and activation parameters constitute special cases. They require the *global* as well as the *local dynamic SRL parameters* of all specified body joints. *Figure 8* shows a simplified case with only the hip and chest joints.



Parameter Name	Calculation Routine	Variables	Target	Refere...	Out...	Stat...	Dyn...
☑ Global Dynamic SRL Hips	Dynamic SRL	Hips			x	x	
☑ Global Dynamic SRL Chest	Dynamic SRL	Chest			x	x	
☑ Local Dynamic SRL Hips	Dynamic SRL	Hips		Base	x	x	
☑ Local Dynamic SRL Chest	Dynamic SRL	Chest		Hips	x	x	
☑ Complexity Trunk	Complexity	Hips,Chest			x	x	
☑ TSM Trunk	TSM	Complexity Trunk				x	
☑ Magnitude Trunk	Magnitude	Hips,Chest			x	x	
☑ Activation Trunk	Activation	Magnitude Trunk				x	
☑ Dyadic Complexity Trunk	Dyadic Parameter	Complexity Trunk			x	x	
☑ Dyadic Magnitude Trunk	Dyadic Parameter	Magnitude Trunk			x	x	

Figure 8. Dependencies between nonverbal parameters.

Rule-checking system. A rule-checking system checks the nonverbal parameter definitions of completeness and consistency for each user action. Therefore, the rule-checking system ensures that APEx can calculate each nonverbal parameter. If the user tries to modify the parameter list in an inconsistent way, APEx displays an error message and cancels the modification made by the user. The rule-checking system checks only active nonverbal parameters and can be completely turned off by using the button ‘Disable All’. Using the button ‘Enable All’ means the rule-checking system will proof every nonverbal parameter against rule violations. Rule violations prevent nonverbal parameter definitions from being enabled.

Output Files

User Interface. The frame ‘Output Files’ is visible under the area of tab pages and allows the user to specify an output folder, output file names, and output file format. In addition, it is possible to activate the processing mode ‘Split Output Files’.

Output folder. By entering a path into the input field ‘Folder for Storing Output Files’ or by clicking on ‘Browse…’ to select a path, the user can specify the folder for the output and statistics files. If the output folder is identical to the input folder, a prefix or a suffix should be entered for the output file names; otherwise, an error message will be displayed later.

Prefix/Suffix. Output files are named as follows: *Prefix + Input file name + Suffix*.

CSV/TSV. Comma separated values (CSV) using semicolons as data delimiter or tab separated values (TSV) using the tab character as data delimiter are supported. For the TSV option, an extension can be entered. The selection of the data format applies to all output files. CSV output files will have the extension ‘.csv’, TSV output files the entered extension.

Statistics file. The name of the common statistics file can be entered in this field.

Split output files. Checking this option will activate the split output file processing mode. In this mode, the output file of each input file will be split into multiple output files with a maximum number of lines according to the number which the user entered in the input field ‘Lines per File’. For each output file, the means of the nonverbal parameters will be calculated and written in a separate file. The output files names contain the label ‘part’ and a consecutive number, the mean file name the label ‘means’. According to the output files, assigned video files will be cut into corresponding video files. The split output file processing mode may be useful for finding sequences of body movements with certain characteristics.

Output and statistical variables. The output variables in the output files and the statistical variables in the common statistics file are listed in Table 2 (p. 22) with cross references to the sections where the variables are explained.

Appendix A: Technical Data of APEx

Name of executable file:	APEx.exe
Platform:	PC with Windows XP, Vista, 7, or higher
Size:	784 KB (802,816 bytes)
Programming language:	Visual Basic 6
Code:	14,500 program code lines (without blank lines)
Version:	1.0.0
Date of compilation:	04/14/2013
Time of compilation:	14:04 AM
Date of publication:	08/01/2013
Name of installation file:	APEx-Setup-v1.0.0.exe
Download location:	www.apex-download.eu
Install instructions:	Download and use the setup file to install APEx.

Appendix B: The Base Position of Static SRL Angles

This section is only relevant if it is intended to use the *static SRL system*. If no base position is specified, the global center of the 3D world is used as the base position. The base position of each model joint is shown in 3D animation software, when all Euler rotation angles are set to zero. For dyadic interactions with sitting individuals, it is recommended that the *static SRL parameters* use the chair as the base position in order to achieve *rotational SRL values* describing flexions from the forward-looking position on the chair. In all other cases, the base positions of the model joints can remain unchanged.

In the case of standing individuals, a position directly facing the interaction partner may be used as the base position by placing an object into the 3D world pointing to the interaction partner and specifying this object as the base in APEx. If the subjects are moving around, and if an object pointing in the direction of the camera is used as a common base for both interaction partners, the *rotational SRL values* will describe flexions related to the camera view and therefore may be more comprehensible when viewing animated video clips.

Appendix C: Python Script to Export Global Values from MotionBuilder

```
#****************************************************************************
# Copyright (C) 2012-2013 Dipl.-Psych. Haug Leuschner, h.leuschner@uni-koeln.de *
#****************************************************************************
from pyfbsdk import *
import pyfbsdk_additions, os, math
from pyfbsdk_additions import *
gExportGlobalData = "Export Global Data"
gExportDirectory = os.path.expanduser('~')+"\documents"

def ExportGlobalData(control, event):
    global gExportGlobalData
    global gExportDirectory
    lSystem = FBSystem()
    lStartTime = lSystem.SystemTime.GetSecondDouble()
    lModelList = FBModelList()
    lVector = FBVector3d()
    lVectorIndex = 0
    lJointCount = 0
    lFrameCount = 0
    lStep = 0.0
    lTime = 0.0
    lSuccess = True

    ## Check prerequisites
    if FBPlayerControl.IsPlaying == True or \
       FBPlayerControl.IsPlotting == True or \
       FBPlayerControl.IsRecording == True:
       FBMessageBox(gExportGlobalData,"While playing, plotting, or recording, \
                                       this script is not executable.","OK")
    else:
        FBGetSelectedModels(lModelList)
        if len(lModelList) == 0:
            FBMessageBox(gExportGlobalData,\
                         "Please select some joints to export their global data.","OK")
        else:
            ## Prompt file name
            lApp = FBApplication()
            lFileDialog = FBFilePopup()
            lFileDialog.Style = FBFilePopupStyle.kFBFilePopupSave
            lFileDialog.Caption = "Export global data to comma separated values file (CSV)"
            lFileDialog.Path = gExportDirectory
            lFileDialog.FileName = lApp.FBXFileName[:-4] + ' - ' + \
                                   lSystem.CurrentTake.Name + '.AB.csv'
            lFileDialog.Filter = '*.csv'
            if lFileDialog.Execute():
                gExportDirectory = lFileDialog.Path
                ## Check if file exists
                lSuccess = True
                if os.path.exists(lFileDialog.FullFilename) == True:
```

```
            if FBMessageBox(gExportGlobalData,"\nThe file " + lFileDialog.FileName +
\
                 " already exists.\nDo yout want to overwrite it?", "Yes", "No") == 2:
                lSuccess = False
        if lSuccess == True:
            ## Write variable names
            f = open(lFileDialog.FullFilename, "w")
            line = "Time [sec];Frame"
            for eachJoint in lModelList:
                line +=  ";" + eachJoint.Name + ":Tx;Ty;Tz;Rx;Ry;Rz"
                lJointCount += 1
            f.write(line+'\n')
            ## get frame count and step
            if hasattr(pyfbsdk, 'FBContainer'):
                lFrameNo = FBPlayerControl().ZoomWindowStart.GetFrame(True)
                lFrameStop = FBPlayerControl().ZoomWindowStop.GetFrame(True)
                lTranslation = FBModelTransformationMatrix.kModelTranslation
                lRotation    = FBModelTransformationMatrix.kModelRotation
            else:
                lFrameNo = FBPlayerControl().ZoomWindowStart.GetFrame()
                lFrameStop = FBPlayerControl().ZoomWindowStop.GetFrame()
                lTranslation = FBModelTransformationType.kModelTranslation
                lRotation    = FBModelTransformationType.kModelRotation
            lFrameCount = lFrameStop - lFrameNo + 1
            lStep = 1.0 / FBPlayerControl().GetTransportFpsValue()
            ## Write global data
            lSuccess = True
            lProgressBar = FBProgress()
            lProgressBar.ProgressBegin()
            lProgressBar.Caption = "Exporting global data of selected objects..."
            FBPlayerControl().GotoStart()
            while lSuccess == True and lFrameNo <= lFrameStop:
                line = str(lTime) + ";" + str(lFrameNo)
                for eachJoint in lModelList:
                    eachJoint.GetVector(lVector, lTranslation, True)
                    if len(lVector) == 3:
                        for lVectorIndex in xrange(3):
                            line += ";" + str(lVector[lVectorIndex])
                    else:
                        line += ";;;"
                    eachJoint.GetVector(lVector, lRotation, True)
                    if len(lVector) == 3:
                        for lVectorIndex in xrange(3):
                            line += ";" + str(lVector[lVectorIndex])
                    else:
                        line += ";;;"
                f.write(line+'\n')
                lFrameNo += 1
                lTime += lStep
                lProgressBar.Percent = int(100.0 * float(lFrameNo)/float(lFrameStop))
                lSuccess = FBPlayerControl().StepForward()
                if (lProgressBar.UserRequestCancell()):
```

```
                        break;
                f.close()
                FBPlayerControl().GotoStart()
                lProgressBar.Caption = "Export of global data finished."
                FBMessageBox(gExportGlobalData,"\nData are successfully written to:\n" + \
                  lFileDialog.FileName + "\nNumber of objects: " + str(lJointCount) + \
                  ", number of frames: "+str(lFrameCount)+"\nDuration of data export: "+\
                  str(round(lSystem.SystemTime.GetSecondDouble() - lStartTime, 0)) + \
                  " seconds.","OK")
                lProgressBar.Percent = 0
                lProgressBar.ProgressDone()

gDEVELOPMENT = False
if gDEVELOPMENT:
    FBDestroyToolByName(gExportGlobalData)
if gExportGlobalData not in pyfbsdk_additions.FBToolList:
    tool = pyfbsdk_additions.FBCreateUniqueTool(gExportGlobalData)
    tool.StartSizeX = 235
    tool.StartSizeY = 270
    x = FBAddRegionParam(-80,FBAttachType.kFBAttachRight,"")
    y = FBAddRegionParam(-35,FBAttachType.kFBAttachBottom,"")
    w = FBAddRegionParam(70,FBAttachType.kFBAttachNone,"")
    h = FBAddRegionParam(25,FBAttachType.kFBAttachNone,"")
    tool.AddRegion("button","button", x, y, w, h)
    lExportButton = FBButton()
    lExportButton.Caption = "Start"
    lExportButton.Justify = FBTextJustify.kFBTextJustifyCenter
    tool.SetControl("button",lExportButton)
    lExportButton.OnClick.Add(ExportGlobalData)
    x = FBAddRegionParam(5,FBAttachType.kFBAttachLeft,"")
    y = FBAddRegionParam(5,FBAttachType.kFBAttachNone,"")
    w = FBAddRegionParam(220,FBAttachType.kFBAttachNone,"")
    h = FBAddRegionParam(185,FBAttachType.kFBAttachNone,"")
    tool.AddRegion("comment","comment", x, y, w, h)
    lComment = FBHBoxLayout()
    tool.SetControl("comment",lComment)
    lLabel = FBLabel()
    lLabel.WordWrap = True
    lLabel.Caption= gExportGlobalData + \
    " (v1.3)\n(c) 2012-2013 Script by Haug Leuschner\n\nThis script exports global “ + \
    “translation and\nrotation data from selected objects into\ncomma-separated values “+ \
    “files (CSV).\n\nYou can leave this window open while\nselecting different objects “+ \
    “and clicking\neach time on 'Start'.\n\nFor dyads, please give one file the “+ \
    “ex-\ntension '.A.csv' (left) and the other one\nthe extension '.B.csv' (right)."
    lComment.Add (lLabel, 240)
else:
    ShowToolByName(gExportGlobalData)
```

Usage: If you copy a text file named ‘ExportGlobalData.py’ containing this script into the subfolder ‘bin\config\PythonStartup’ of MotionBuilder’s installation folder, a menu item ‘Export Global Data’ will be available in the ‘Python Tools’ menu of MotionBuilder.

Appendix D: Calculation Functions and Their Input Variables

Table 1

Default Input Variable Names and Their Meanings

Default Input Variable Label	Default Input Variable Name	Meaning
Joints		
Base	Base	Object used as base (leave blank or specify object, e.g., chair)
Hips	Hips	Root joint (at the bottom of the hips)
Chest	Chest	Chest joint (at the bottom of the chest)
Head	Head	Head joint (at the bottom of the head)
Arm L	Arm Left	Left shoulder joint
Elbow L	Elbow Left	Left elbow joint
Hand L	Hand Left	Left hand joint
Leg L	Leg Left	Left hip joint
Knee L	Knee Left	Left knee joint
Foot L	Foot Left	Left ankle joint
Arm R	Arm Right	Right shoulder joint
Elbow R	Elbow Right	Right elbow joint
Hand R	Hand Right	Right hand joint
Leg R	Leg Right	Right hip joint
Knee R	Knee Right	Right knee joint
Foot R	Foot Right	Right ankle joint
Markers		
Chin	Chin	Marker at the bottommost point of the head
Top	Top	Marker at the topmost point of the head
Nose	Nose	Marker between the eyes (same height as ears)
Ear R	Ear Right	Marker at the right ear
Ear L	Ear Left	Marker at the left ear
Chest L	Chest Left	Marker at left nipple of chest
Chest M	Chest Middle	Marker at the back (same height as nipples)
Chest R	Chest Right	Marker at right nipple of chest
Hips L	Hips Left	Marker at left hip joint (‘Leg L’)
Hips M	Hips Middle	Marker at the back (same height as hip joints)
Hips R	Hips Right	Marker at right hip joint (‘Leg R’)
Hand L O	Hand Left Outside	Marker at outer side of left wrist
Hand L F	Hand Left Finger	Marker at the top of the left middle finger
Hand L I	Hand Left Inside	Marker at inner side of left wrist
Hand R O	Hand Right Outside	Marker at outer side of right wrist
Hand R F	Hand Right Finger	Marker at the top of the right middle finger
Hand R I	Hand Right Inside	Marker at inner side of right wrist
Camera	Camera	Camera of 3D animation world
Interest	Interest	Interest of camera

Note. The input variable names of human 3D model joints rely more on the body parts being moved than their anatomically notions used with human joints, e.g. the left shoulder joint is named ‘Arm L’ and the right hip joint is named ‘Leg R’.

Table 2

Calculation Functions With Their Input, Output, and Statistical Variables

Calculation function	*Description, tables, and formulas**	*Input variables (min.–max. number)*	*Target variables (min.–max. number)*	*Reference system (min.–max. number)*	*Output variables (in output file)*	*Statistical variables (in statistics file)*
Static SRL (global version)	Description p. 27, 37, 33 Equation (4), p. 30 Equation (5)-(7), p. 31	Every input variable, but should be a joint (1-1)	-	Every input variable, usually 'Base' (0-1)	Global Static SRL Sagittal Global Static SRL Rotational Global Static SRL Lateral	M, SD, MIN, and MAX of each output variable
Static SRL (local version)	Description p. 27, 37 Equation (4), p. 30 Equation (5)-(7), p. 31	Every input variable, but should be a joint (1-1)	-	Input variable of parent (1-1)	Local Static SRL Sagittal Local Static SRL Rotational Local Static SRL Lateral	M, SD, MIN, and MAX of each output variable
Dynamic SRL (global version)	Description p. 33, 37 Equation (8), p. 34 Equation (5)-(7), p. 31	Every input variable, but should be a joint (1-1)	-	Leave blank (0-0)	Global Dynamic SRL Sagittal Global Dynamic SRL Rotational Global Dynamic SRL Lateral	M, SD, MIN, and MAX of each output variable
Dynamic SRL (local version)	Description p. 35, 37 Equation (9), p. 36 Equation (5)-(7), p. 31	Every input variable, but should be a joint (1-1)	-	Input variable of parent (1-1)	Local Dynamic SRL Sagittal Local Dynamic SRL Rotational Local Dynamic SRL Lateral	M, SD, MIN, and MAX of each output variable
Complexity	Description p. 39, 41 Table 3, p. 43	Each set of input variables with dynamic SRL parameters (both global and local version) (1-n)	-	-	Global Dynamic Complexity Local Dynamic Complexity Translational Complexity Joint Complexity	CBM and CAP of each output variable
TSM	Description p. 40, 41 Table 4, p. 44	Each complexity parameter previously on the list (1-1)	-	-	-	TSM TSM (only A) TSM (only B) TSM (A and B) TSM (A and/or B)
Magnitude	Description p. 40, 41 Table 5, p. 45	Each set of input variables with dynamic SRL parameters (both global and local version) (1-n)	-	-	Global Dynamic Magnitude Local Dynamic Magnitude Translational Magnitude	MBM and MAP of each output variable
Activation	Description p. 40, 41 Table 6, p. 46	Each magnitude parameter previously on the list (1-1)	-	-	-	7 statistical variables, see 'Activation' in Leuschner (2013)

Calculation function	*Description, tables, and formulas**	*Input variables (min.–max. number)*	*Target variables (min.–max. number)*	*Reference system (min.–max. number)*	*Output variables (in output file)*	*Statistical variables (in statistics file)*
Symmetry	Description p. 67 Equation (10), p. 64 Equation (11), p. 64 Table 9, p. 66	Every input variable, usually a joint of a extremity (1-1)	Every input variable, usually the appropriate joint of the other body side (1-1)	Every input variable, but should be central, usually chest for upper and hips for lower extremities (1-1)	Symmetry	M, SD, MIN, and MAX of the output variable
Distance	Description p. 68 Equation (12), p. 66 Table 10, p. 66	Every input variable, usually a joint of a extremity (1-1)	Every input variable, usually the corresponding joint of the other body side (1-1)	-	Distance	M, SD, MIN, and MAX of the output variable
Expansion	Description p. 67 Equation (12), p. 66 Table 11, p. 68	Every set of input variables, usually the joints of the trunk (1-n)	Every input variable, usually a joint of a extremity (1-1)	-	Expansion	M, SD, MIN, and MAX of the output variable
Folded	Description p. 68 Equation (12), p. 66 Table 12, p. 70	Folded arms: 'Hand L, Elbow L' Folded legs: 'Foot L, Knee L' (*for other values edit registry*)	Folded arms: 'Hand R, Elbow R' Folded legs: 'Foot R, Knee R' (*for other values edit registry*)	-	Folded	M, SD, MIN, and MAX of the output variable
Crossed	Description p. 68 Equation (12), p. 66 Table 12, p. 70	Crossed legs: 'Foot L, Knee L' (*for other values edit registry*)	Crossed legs: 'Foot R, Knee R' (*for other values edit registry*)	-	Crossed	M, SD, MIN, and MAX of the output variable
Openness	Description p. 68 Equation (12), p. 66 Table 12, p. 70	Arms: Distance Elbows & Hands Legs: Distance Knees & Feet (2-2)	Arms: Folded Arms Legs: Folded & Crossed Legs (1-2)	-	Openness	M, SD, MIN, and MAX of the output variable
Direction (forward) Direction (backward)	Description p. 71 Eq. (13)-(16), p. 72-74 Table 13, p. 75	Three input variables in the following order: (1) left marker (2) middle marker* (3) right marker	Every input variable, usually nose, chest, or hips **Note: if the middle marker is on the backside, then choose function 'Direction (backward)'!*	-	3D Deviation 2D Deviation Horizontal 2D Deviation Vertical	M, SD, MIN, and MAX of each output variable
Dyadic Proxemics	Description p. 76 Equation (12), p. 66 Table 14, 15, p. 77	Each set of input variables (1-n)	Each set of input variables (1-n)	-	Dyadic Proxemics	M, SD, MIN, and MAX of the output variable
Dyadic Mimicry	Description p. 40 Equation (5)-(7), p. 31 Equation (8), p. 34 Equation (17), p. 79 Table 16, p. 80	Each set of input variables, should be body joints (1-n)	-	Every input variable, should be chest or hips (0-1)	Dyadic Rotational Mimicry Dyadic Mirror Mimicry	M, SD, MIN, and MAX of each output variable
Dyadic Parameter	Description p. 81 Table 17, p. 82	Each nonverbal parameter previously on the list	-	-	*For each output variable:* Common Expression A and B Percentage contribution of A Net Contribution of A Net Percentage Contribution of A	M, SD, MIN, and MAX of each output variable

Calculation function	*Description, tables, and formulas**	*Input variables (min.–max. number)*	*Target variables (min.–max. number)*	*Reference system (min.–max. number)*	*Output variables (in output file)*	*Statistical variables (in statistics file)*
Camera Framing	Description p. 83 Equation (18)-(22), p. 86 Equation (23), p. 86	Every input variable, usually top of head (1-1)	Every input variable, usually bottom of head (1-1)	-	Camera Framing	M, SD, MIN, and MAX of the output variable
Camera Proxemics	Description p. 88 Equation (18)-(22), p. 86 Equation (24), p. 88	Every input variable, usually top of head (1-1)	Every input variable, usually bottom of head (1-1)	-	Camera Proxemics	M, SD, MIN, and MAX of the output variable
Pixel Difference	Description p. 89 Equation (25), p. 89	-	-	-	Pixel Difference	MBM and MAP of the output variable
Less Than	Returns 1, if nonverbal parameter is less than number or distance	Each nonverbal parameter previously on the list (1-1)	Choose "(Enter number)" or choose two joints meaning the distance between them	-	*For each output variable of the selected parameter:* Label + "Less Than" + Target	M, SD, MIN, and MAX of each output variable
Greater Than	Returns 1, if nonverbal parameter is greater than number or distance	Each nonverbal parameter previously on the list (1-1)	Choose "(Enter number)" or choose two joints meaning the distance between them	-	*For each output variable of the selected parameter:* Label + "Greater Than" + Target	M, SD, MIN, and MAX of each output variable
Addition	Sum of parameters	List of nonverbal parameters previously on the list (1-n)	-	-	*For each output variable of the selected parameters:* Label + "plus" + Label + …	M, SD, MIN, and MAX of each output variable
Subtraction	Difference of parameters	List of nonverbal parameters previously on the list (1-n)	Nonverbal parameter, from which each parameter of the variable list is subtracted (1-1)	-	*For each output variable of the selected parameters:* Target + "minus" + Label + …	M, SD, MIN, and MAX of each output variable
Multiplication	Product of parameters	List of nonverbal parameters each calculated previously (1-n)	-	-	*For each output variable of the selected parameters:* Label + "times" + Label + …	M, SD, MIN, and MAX of each output variable
Division	Quotient of parameters	List of nonverbal parameters each calculated previously (1-n)	Nonverbal parameter, which is successively divided by the parameters of the list (1-1)	-	*For each output variable of the selected parameters:* Target + "by" + Label + …	M, SD, MIN, and MAX of each output variable
Absolute Value	Absolute value of nonverbal parameter	Each nonverbal parameter previously on the list (1-1)	-	-	*For each output variable of the selected parameter:* Label + "(Absolute Value)"	M, SD, MIN, and MAX of each output variable
Dynamic Parameter	Difference of a value to the value of the previous time point	Each nonverbal parameter previously on the list (1-1)	-	-	*For each output variable of the selected parameter:* Label + "(Dynamic)"	M, SD, MIN, and MAX of each output variable
Coord. Transf.	Coordinate transformation of joint data	Every input variable (1-1)	*Note: Can also be used to load data, leave "Reference" blank.*	Every input variable (1-1)	TransX, TransY, TransZ, RotX, RotY, RotZ	M, SD, MIN, and MAX of each output variable

* Adapted from "Microanalysis of nonverbal communication: Development of a nonverbal research method using high-performance 3D character animation" by Leuschner (2013).

Appendix E: Examples of User-Defined Nonverbal Parameters

Arms-Akimbo Posture

Parameter Name	Calculation Fun...	Variables	Target	Ref...	Out...	Stat...	Dyn...
☑ Distance Hand-Leg R	Distance	Hand R	Leg R				
☑ Distance Hand-Leg L	Distance	Hand L	Leg L				
☑ Distance Hands to Hips	Addition	Distance Hand-Leg R,Distance Hand-Leg L					
☑ Arms-Akimbo	Less Than	Distance Hands to Hips	Hand R,Hand R F		x	x	

Figure 9. Settings for a user-defined parameter ‘Arms-Akimbo’.

Height Difference of Ears

Parameter Name	Calculation Fun...	Variables	Target	Ref...	Out...	Stat...	Dyn...
☑ Data Ear L	Coord. Transform.	Ear L		Base			
☑ Data Ear R	Coord. Transform.	Ear R		Base			
☑ Difference of Ears	Subtraction	Data Ear L	Data Ear R		x	x	

Figure 10. Settings for a user-defined parameter ‘Ear height difference’.

References

Leuschner, H. (2013). *Microanalysis of nonverbal communication: Development of a nonverbal research method using high-performance 3D character animation.* Doctoral dissertation, University of Cologne, Germany. Retrieved from http://www.apex-download.eu.

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