CMAP3 GUIDEBOOK
## CONTENTS

Preface ................................................................................................................................. 3

1. Overview .......................................................................................................................... 4

2. Important Reminders ...................................................................................................... 6

3. Installing CMAP3 .......................................................................................................... 7

4. Defining CMAP3 Projects ............................................................................................ 9
   4.1 Defining the S number and Clusters ............................................................................ 9
   4.2 Changing n/S ................................................................................................................ 10
   4.3 Duplicating Projects .................................................................................................. 10
   4.4 Compacting Project Database .................................................................................... 11
   4.5 Deleting Projects ........................................................................................................ 11

5. Raw Data Input ............................................................................................................. 11
   5.1 Preparing Data ........................................................................................................... 11
   5.2 Manual Entry of Data .................................................................................................. 12
   5.3 Causal Link Specification (direction +/-, W values / group sign) .............................. 15
   5.4 Importing Data .......................................................................................................... 16
       5.4.1 Importing Standard Term Vocabulary (STV) (Concept Pool) ......................... 17
       5.4.2 Importing NLUs by Concept Selection List (CSL) ............................................. 19
       5.4.3 Importing Causal Links Data (NCUs) using PCMs ............................................ 20
       5.4.4 Downloading Large Sets of NLUs (RDWS) ....................................................... 21
       5.4.5 Ensuring Import File Compatibility ................................................................. 23
   5.5 Deleting Data ............................................................................................................. 23
   5.6 Exporting Data tables ................................................................................................ 24

6. Standardizing and Standard Term Vocabulary (STV) ................................................ 26
   6.1 Why Standardizing (Coding)? ................................................................................... 26
   6.2 Standard Term Vocabulary (STV) ............................................................................. 27

6.3 NLU/SNT Matrix – Iterative STV Development ......................................................... 27

6.4 STAG Replacement ..................................................................................................... 29

6.5 Parallel Projects and STVs ......................................................................................... 29

6.6 Primary/Secondary STV Language (STERM/STENG) ............................................. 30

7. Generation of Output Data (SCU/SNT) .................................................................... 31
   7.1 Generating Module and Parameters ......................................................................... 31
   7.2 Standard Causal Units (SCU) .................................................................................... 34
   7.3 Standard Node Terms (SNT) ..................................................................................... 37

8. CMAP3 Analysis Tools ............................................................................................... 38
This guide is about CMAP3 software (v. 3.1.5) for comparative and composite causal mapping (CCM). It describes the logic and structure of the application, its different modules and their functions, focusing on the technical aspects of using CMAP3. To understand the software and the different ways it can be used, however, a basic understanding of the theoretical notions and methodological approaches in CCM research is highly desirable. Researchers and practitioners, who have not been using CCM or related methods, can find discussions and different positions about these topics in related literature and research papers¹. A recent overview of CCM methods and CMAP3 is: Laukkanen, M.: Comparative Causal Mapping and CMAP3 Software in Qualitative Studies, published in Forum: Qualitative Social Research, 13(2), 2012, and downloadable free at: http://nbn-resolving.de/urn:nbn:de:0114-fqs1202133 (accessed 04.06.17) or via http://www.uef.fi/cmap3.

A new practical resource to consider is Comparative Causal Mapping: The CMAP3 Method (by Mauri Laukkanen and Mingde Wang, Gower, 2015)². At present, the book is the only general introduction to comparative and composite (document-based) causal mapping. It discusses in an accessible form the theoretical underpinnings and current methodological approaches of CCM research and the different techniques of CCM data elicitation and analysis. It also contains examples of real CCM studies using semi-structured, structured comparative and composite (documentary) causal mapping methods and CMAP3. To connect the present technical instructions and this book’s discussion of CCM research issues, methods and techniques, this guidebook contains some references to the book (called hereafter CCM Book 2015).


1. OVERVIEW

CMAP3 is based on the notion that a cause map (cognitive map, influence diagram, digraph, etc.) consists of concept pairs. The concepts (cause map nodes) refer to some entities or phenomena (A, B, C etc.), which are assumed to be causally or temporally linked (A ➔ B, C ➔ D, etc.). Using CMAP3, the node/concept pairs (dyads) can be processed, combined, aggregated and analysed and also transformed into visual causal maps.

CMAP3 is built of integrated modules (Figure 1), which are used in the entry and coding of raw data, generation of standardized (coded) output data and its analysis and computing of quantitative measures and indicators. CMAP3 supports both semi- or low-structured and structured CCM methods and document based composite causal mapping. In the current version, the maximum number of respondents or other distinct data sources such as documents in a single CMAP3 project is N/S =< 50.

When processing data CMAP3 uses databases/tables. Some of these are created when a new CMAP3 project (see below) is set up; some are temporary and created each time anew by the respective module. For purposes of processing and brevity CMAP3 uses certain terminological conventions and acronyms. The permanent databases, which are contained in the project file (extension: cmdb), are as follows:

1) *Natural language units* (NLU) database stores the original concepts (cause map nodes) in the raw data.
2) *Natural causal units* (NCU) database stores the original node-dyad causal link information.
3) *Standard term vocabulary* (STV) database is necessary for coding NLU. The STV can be compared to a coding scheme in content analytic studies.
4) *Standard causal units* (SCU) database contains the generated standardised (coded) concept-concept causal pairs and information about the SCU incidence by Ss, Clusters, etc.
5) *Standard node terms* (SNT) database contains the standardised concepts (cause map nodes) in the generated causal map system, represented by the SCUs.
6) *Parameter database* stores the number of respondents (S) and the Clusters (C) as defined in the Project Manager module (see below).

Databases 1 - 5 can be accessed, viewed and edited/sorted using the corresponding module as discussed below. Their contents can also be *exported* to be viewed, processed and analysed by *MS Excel™* as spreadsheet files (xls, xlsx). The parameter database (6) is invisible and not directly accessible.

In addition to the 6 databases a separate *Project Log* will be created for notes when a CMAP3 project is set up. The log is a simple *text file*, which is accessed/edited using the Project Manager Module or Windows text editor. As noted, when processing some types of output CMAP3 uses temporary databases, for instance,
when calculating numerical indicators or creating Focal Maps, which are not stored permanently. They can be exported, edited and printed as spreadsheet files as long as they are displayed by the respective module

CMAP3 does not have an integrated capability for producing visual cause maps and printing the databases. Instead, uses external applications in the same computer. For graphical maps, cause map components (SCU sets) can be exported to the concept mapping application CmapTools or drawing software such as MS PowerPoint™ (see section 9). For printing a data table it must be first exported to MS Excel™ and formatted as the user sees fit. Using dedicated applications instead of necessarily somehow constricted integrated functions provides more options and better functionality.

CMAP3 is designed for Windows computers (PCs) running with Windows XP, Vista, 7, 8 or 8.1 (not 8 RT or 8.1 RT) and 10 operating systems. Importing and exporting (down/uploading) data or printing the contents of a database file require that MS Excel has been installed and is available in the same computer (NB: please see footnote 4 below). To export cxl-files for drawing visual/graphic causal maps with IHMC CmapTools or to embed Focal Map text-files to MS PowerPoint, they must obviously be available in the same PC as CMAP3.

Before downloading and installing CMAP3, it is recommended for new users to first evaluate the applicability of CCM methods and CMAP3 for the planned task using the sources noted in the Preface. For a more detailed discussion of CCM and CMAP3, please see CCM Book 2015 and its list of references.

CMAP3 is a non-commercial application, developed as an academic project of the Department of Business, University of Eastern Finland (UEF), Kuopio Campus. It has been supported by the Finnish Foundation of Economic Education (Liikesivistysrahasto). Downloading and using the software and the support documents for research purposes is free.
2. IMPORTANT REMINDERS

1. CMAP3 has been tested and used in actual CCM research and found to function stably and as designed. However, unforeseen problems can always occur, caused by computer issues or unusual combinations of operations and/or a specific Windows environment. **It is understood that the user is aware of the related risks, observes normal safety measures, and accepts the sole responsibility for using the application.**

2. The CMAP3 setup file is **free of viruses or malware.** However, when downloading, some Internet Security software may routinely put also this file **in quarantine,** from where it must be removed first.

3. **IMPORTANT:** When **installing CMAP3**, it **must** be done as **System Administrator**, in other words, by opening the Setup File "**As Administrator**" (right-click menu, 2\textsuperscript{nd} or 3\textsuperscript{rd} command line usually). It is also **recommended** to **start** the application **As Administrator**, at least in the beginning.

4. When using CMAP3, each task must be finished properly by closing/exiting the accessed module and function before continuing to the next task. Doing so ensures that the accessed files which are often interconnected will be properly closed and appropriately accessible again.

5. To protect against losing data, time and effort, it is warmly recommended to use common sense countermeasures such as (a) saving one’s work often and (b) making regularly copies of the **project’s cmdb-file**, which contains the most work intensive data (NLU, NCU, STV). All output files and interim tables can be easily regenerated. One option is to use the **duplicate/copy-command** of Project Manager to create a copy of the **active** project’s files or to use normal Windows file management tools, with which the copies can also be returned to the CMAP3 Data folder when necessary.

6. If the application stalls unexpectedly or terminates after an error message, the problem is usually solved by **closing** and/or **restarting the application**, sometimes by restarting the computer, too. If the setup was irregular or the computer or the application are used not observing normal sound practices and conventions, uninstalling and reinstalling CMAP3 can be used to create a clean beginning again.
3. INSTALLING CMAP3

The installation of CMAP3 in a Windows workstation is automatic using the downloaded CMAP3 setup file. As noted above, it must be opened and run as System Administrator. The process installs CMAP3 and creates two folders: a CMAP3 folder for the application and its support files and a Documents subfolder called CMAP3 Data, where the project file/s will be stored. In addition, two demonstration projects (CCM_Case1, CCM_Case2) will be installed. Details of these projects can be found in their Project Logs. To remove CMAP3 from the computer the normal Windows Uninstall procedures are used.

As noted, when starting CMAP3 for the first time, it is recommended to do this As Administrator by right-clicking the CMAP3 icon and the appropriate alternative. When started, CMAP3 displays the Main menu (Figure 3.1) listing the different modules and an information window with contact addresses. The modules are accessible also in the Functions menu or by pressing a function key, e.g., F2 for the Project Manager.

![CMAP3 Main Menu / Opening Interface](image)

The information window can be turned off in the <Tools/Settings > menu and accessed again in Help/About. In Tools/Settings, the user can define how CMAP3 starts. The options are the Start screen (Main menu), the
Project Manager or the last opened module. When working longer with a given project, the last option is convenient. Furthermore, two font sizes can be chosen. The CMAP3 window can be resized by drawing with the mouse.

At the outset, the first opened default project is the first demo project (CCM_Case1.cmdb). In normal use, CMAP3 opens the last accessed project when starting. The bottom row displays the name of the active project and its file path. When new projects have been created and are available in the CMAP3 Data folder, they are opened and set active by the <File/Open> command. This opens the folder and displays the existing project files. If a different folder was used to store the projects, which is also possible, the last accessed project will be located and opened there.

When moving and copying CMAP3 projects it is important to include both the cmdb-file and the project's Log txt-file. Both files must be available in the same folder.

![CMAP3 Project Manager](image)

**Figure 4.1** CMAP3 Project Manager
4. Defining CMAP3 Projects

A CMAP3 project corresponds to a single CCM study case, which has a given number of respondents or data sources (here after S/Ss). A project is defined in the Project Manager module (Figure 4.1), accessed through the Main Menu, or opens automatically when a new project starts (command File/New).

At the outset when defining a new project, all fields are empty except for the date (=current computer date). The project can be given any name and CMAP3 attaches automatically the cmdb extension to it. There is no limit to the number of CMAP3 projects (assuming adequate computer storage capacity).

The Project Log window can be used for note to describe the project, its goals, data, operations, notes for the next tasks, etc. The log’s text can be copy/pasted to other documents (and vice versa). It can also be accessed/edited directly by opening the project's log file in the CMAP3 data folder. When setting up a new Project, there must be some text in the Project Log window; it cannot be left empty.

The Project Screen has three command buttons. The button <Save> stores the project log and parameter data and later all changes made to them. The <Backup/Duplicate Project> button is basically a Windows Save As command (section 4.3). <Close> shuts the Project Manager and opens the Main Menu.

4.1 Defining the S number and Clusters

Entering the number of respondents (n/S) or distinct data sources like documents is compulsory information. The current version of CMAP3 allows for an n/S of =< 50 (S01 – S50). In typical CCM studies, the S number is known at the outset as defined by the research plan. In sequentially progressing studies, where the S number is often based on saturation, the n/S is not known at the outset. For these cases, CMAP3 enables adjusting the n/S upwards. In composite causal mapping using documentary sources, differentiating the separate data sources may be unnecessary and only one S (S01) is defined. If the user wants to keep track of the data sources, e.g., each document is assigned its own S number. Although n/S can be altered later (see section 4.2), it is a good idea to try to define it correctly and at least avoid setting the number too low.

CMAP3 Project Manager provides for defining up to 5 Clusters of Ss and their inclusion criteria. Clusters are not obligatory. They are defined by entering a list of (valid) S-numbers into the corresponding cluster field (S01, S02 etc., separated by a comma) and an inclusion value. For example, in Figure 2, C1 was defined as consisting of three Ss with a threshold TF (total frequency) value of = > 2. When generating SCU/SNT output CMAP3 will observe this. For example, for an SCU to be considered to belong to C1, two of the included three Ss must possess an NCU, which corresponds to that SCU (as coded). All such SCUs would
constitute C1’s causal map. In research practice, study objectives, theoretical criteria and actual observations influence the clusters and inclusion criteria that will be defined if at all (see CCM Book 2015).

Notably, if necessary, a given S can be a member in more than one cluster. The user can also change the cluster definitions, e.g., to test the outcomes of different cluster compositions and/or inclusion criteria values and their impact on the SCU/SNT output.

In some CCM studies it is important to group Ss and analyse the groupings separately in causal map and structural indicator terms (Section 8.3). Using S clusters does not enable this. It is, however, possible to generate SCU/SNT data tables and indicator sets for S groups by using W values (see Section 5.3, 7.1).

4.2 Changing n/S

The n/S entered when setting up a project at the outset defines the project's data table structures. Raw data can be entered only for the defined n/S. However, n/S can be adjusted later if/when necessary.

When the user changes the n/S, CMAP3 issues an alert. It is important to observe note, first, that if the user proceeds and sets the new n/S lower than the original one, the data table structures will be downsized to reflect the smaller number. It also follows that if there was NLU and NCU data entered for Ss with the higher numbers, that data will be erased permanently and the eventually generated SCU and SNT tables, too.

Conversely, if the new n/S is set higher, there cannot be any NLU and NCU data to delete. Only the contents of the SCU and SNT tables will be erased, but they can be quickly regenerated with no data loss.

4.3 Duplicating Projects

The Project Manager module has a <Backup/Duplicate Project> button. Essentially, this is a Windows Save As command. It can be used, first, for backing-up a project's cmdb-file, e.g., to a USB memory stick. Second, it can be used for creating one or more parallel CMAP3 projects.

In CMAP3, all projects are operatively independent of each other. However, projects (their databases) can contain same data, e.g., raw data (NLU, NCU) or use the same standard term vocabulary (STV). This is achieved by copying/duplicating an existing project and saving it under a different project name. This is useful, e.g., when two projects must have the same raw data but will be using different levels of STV/coding (for other uses, see CCM Book 2015).
4.4 Compacting Project Database

In database applications such as CMAP3, the database file, in this case the cmdb file holding the Project's data tables, tends to expand in size gradually each time it is accessed\(^3\). The growth does not normally impede performance or influence data contents or processed results. Over time, expansion can be harmful, corrupt the file and slow performance in addition to requiring more space. Therefore, it is useful to occasionally compact the database using the menu command <File/Compact project database>. This influences only the active project's cmdb file. After compacting, the file size before and after the operation is shown.

4.5 Deleting Projects

To remove a CMAP3 project from the computer the user follows the standard Windows procedures. The project's cmdb and log txt files are located and deleted. However, the currently active project (shown in the Opening Screen's bottom line) must not be deleted. If it must be deleted, a different project must be first activated (selected) using Project Manager. Before deleting projects, it may be important to ensure that there are backup copies or that no critical, work-intensive data will be deleted irreversibly.

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5. Raw Data Input

Original or raw data in comparative/composite causal mapping (CCM) studies consists mainly of interlinked causal statements that something (A) influences something else (B) or that B is dependent on or follows temporally A. In CMAP3 the data (NLU, NCU) is usually entered by keyboard and mouse, but in some cases it can be imported (section 5.4) as MS Excel workbook/sheet files.

5.1 Preparing Data

In CCM studies, which use interview or documentary/text data, the data must usually be first converted (transcribed) into a form, which enables an efficient and reliable keyboard entry into CMAP3. This often also supports a provisional or final coding of the original concepts. A practical manual method is to use Raw Data Sheet (RDS) forms (see Laukkanen Wang 2015, Chapter 5.1). This technique can be computerized and realized by using raw data worksheets (RDWS), as explained below in chapter 5.4.4 and in Figure 5.6, which also conveys the idea of an RDS.

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\(^3\) For a technical explanation of the expansion and why a database should be compacted, see: [https://support.office.com/](https://support.office.com/)
Data entry in CMAP3 assumes that a RDS (or RDWS) page contains data only for one S and has <= 50 NLUs/rows. There can be less *but not more* than 50 NLUs per one RDS. If an S has more NLUs, simply more RDSs are used. The maximum number of RDSs per S is = < 99, which has been found to enable a sufficiently large number of NLUs (4950) per one S. The NCUs are also transcribed/noted on the respective RDS NLU-rows. The NCU number (per page or total) is *not limited*. The above conventions are *critical* for the correct entry of data in the databases and for the creation of NLU and standardizing signifiers, on which the computer processing is dependent. In addition, using RDSs or RDWSs creates an *audit trail* for tracking of the origins of the standardized output (SNT, SCU) back to the original raw data.

Different interview note keeping and RDS forms and alternative techniques for handling raw data and for coding the original concepts are discussed in more detail in *CCM Book 2015*.

### 5.2 Manual Entry of Data

Keyboard/mouse entry of raw data into a CMAP3 project uses two modules. First, the *Node Data & Standardizing* module (here after the **NLU module**, Figure 5.1) is used to input the original concepts (NLUs), and the project’s **Standard Term Vocabulary** (STV). The NLU module is used also for standardizing (coding) the NLUs (see Section 6), i.e., to link the NLUs with a respective standard node term (SNT) in the STV. When the NLUs have been entered, the original causal links (NCU) data can be input using the *Causal Links Data (NCU) Module* (Figure 5.2) (see below).

The NLU module’s upper window displays the **NLU data table**, blank at the outset. The user enters the first NLU by giving the S number, the RDS and the row number of the respective NLU. There is a REM field for optional comments. Furthermore, assuming the *standard term vocabulary* (STV) (see Section 6) is available (in a preliminary or final form), the appropriate standard term is located in the lower STV Input/Edit window and selected with a mouse click. This brings the selected standard term (= STAG and STERM) into the respective NLU field. By clicking the <Save> button, CMAP3 creates a signifier called **NTAG** for the NLU and enters the NTAG, the NLU, the eventual REM text, and, if standardized/coded at entry, the NLU’s STAG and corresponding STERM into the NLU data table. They will be visible in the upper NLU window.

Notably, it is possible to enter the NLUs *unstandardized* and do the coding done later. If an *entry error* was saved, clicking the respective NLU row in the upper window brings the entered contents into the respective cells, which also enables remarks, changing the wording of the NLU or a different ST/STAG.
Figure 5.1  Node Data & Standardizing (NLU) module

Usually, it is practical to check/activate the *Auto increment* function and to also select/check the *USE S-number for filtering* option. As long as the NLU entries have not been saved, the data in the cells can be removed by <Clear> command. A new S or RDS page is entered by the commands <Next S> and <Next page>. The <Delete> command removes the selected NLU from the database.

As in most Windows applications, NLUs can also be *copy/pasted* to the NLU module fields assuming the NLU data is available in the computer in a digital form such a PDF or doc file.

The user can view the NLU database and sort the NLUs by mouse clicking any of the upper window column titles. E.g., by clicking the STAG column, the NLUs will be displayed by ST categories for examining the standardizing’s consistency, appropriateness, etc.

As all CMAP3 project data tables, NLU data too can be exported to *MS Excel* by the <Export> button assuming that this application is available. This does not alter the data tables’ contents. Browsing and analysing especially large NLU data tables can be more convenient using *MS Excel*. The contents can also be
sorted and manipulated and counting and logical operations applied. As noted earlier, MS Excel is also necessary to print the NLU data table, e.g., for checking or developing coding.

In manual keyboard entry it is assumed that the original NCUs are available in the RDSs (or RDWS, see above). NCUs contain the information about the original causal links between two or more NLUs. In some CCM studies the causal links may also be specified. This information (+/-, W, see Section 5.3) must then be available in the RDSs, too.

In CMAP3 the entry of NCUs requires no or only little typing. In the upper NLU window, the user selects first (by mouse click) the Preceding NLU. This brings the “cause” NLU with its NTAG to the upper cells. Next, the "effect" or Following NLU (i.e. it’s NTAG, showing the row number) is selected and brought similarly to the lower cells.
In case NCU specification is used, the link information on the respective RDS row is noted and entered. If the link is inverse, the default value/direction (= direct = +) is changed by clicking the < D +/-> toggling the plus sign into a minus.

If the W (Weight) indicators are used (for different options, see Section 5.3 below), the W value is keyboard-entered into its cell, if it differs from default value \( W = 1 \). When all is done, clicking <Save> adds this NLU-NLU pair with specification data to the NCU data table. It appears in the lower NCU window.

The command <Clear> erases erroneous entries before saving. A saved but erroneous NCU can be removed from the NCU database by selecting that NCU in the NCU window and the <Delete NCU row> command.

Using the <S filter> enables displaying all Ss' or only a specific S's NLUs and NCUs. Using this option makes it easier to pick the NLUs and also check that the NCU entry is what was intended.

A further useful NCU entry command is <Clear preceding after save>. This is used when entering NCUs of such NLUs, which have several effects, i.e. “E-rows”. In some cases it is convenient to keep the <Preceding NLU> contents unchanged by keeping the tick box unticked if there are several E-rows/NLU.

5.3 Causal Link Specification (direction +/-, W values / group sign)

In CMAP3, NCUs can be specified in two dimensions corresponding the traditional CCM practices. The dimensions are usually defined as the direction of the causal influence and the link's strength or importance. The researcher can obviously define the available dimensions differently.

In CMAP3, the causal link's influence direction (D) is either direct (+) or inverse (-). The former (+) is the default value and does not need to be entered. To signify an inverse relationship, a minus (-) sign is keyboard entered into the <D+/-> field.

The second dimension is NCU weight (W). The optional value range is 0 <= W <= 5. W values of 1, 2 and 3 have been typical in CCM-studies, referring to a weak, moderate or strong causal influence, as perceived by the Ss. Some studies may need to differentiate statements that something does not influence something else.

An important option is to use W values for grouping Ss. In this case, obviously the NCUs of a given S will be entered all with the same W value, signifying that S's group membership. This is comparable to S clusters (Section 4.1), but with the key difference that it enables generating SCU/SNT data separately for each S.
grouping. The SCU/SNT data tables and the quantitative indicators (Section 8.3) provide a basis for describing and analysing the differentiated S groupings. When using this option, the correct setting of the generation parameters for W values must be observed (Section 7.1).

If W values are not used, the default value is \( W = 1 \), which can be ignored. If W values are used, their research meanings and implications need to be observed also when generating output data tables (see Section 7). The defined W parameter influences what will be included/displayed in the SCU and SNT data tables and later the quantitative indicators. The calculation method CMAP3 uses when there are different W values is discussed below in section 7.1.

5.4 Importing Data

Data importing enables using CMAP3 especially in structured CCM and sometimes also in document/text based composite causal mapping. Related research examples and different techniques of data acquisition are discussed in CCM Book 2015. This section describes the methods and conventions in importing data.

In principle, importing parallels manual data entry. A CMAP3 project must be first set up to create the data tables for receiving data. The difference is that the data is now imported whereby CMAP3 reads the MS Excel™ files (.xls, .xlsx)\(^4\), where the SVT, NLU and NCU data have been entered by keyboard or/and copy paste. The worksheet files must fulfill certain formal criteria so as to enable CMAP3 recognize the files and to import the data correctly concerning, first, correctly naming of the MS Excel files and, second, the correct column structure and names of the worksheets. These are explained below.

To understand importing in CMAP3 and its uses, it is helpful to examine how it would proceed in concept pool CCM (see CCM Book 2015). There would be following stages (the conventions are explained below):

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\(^4\) Technical note: The function of importing data as .xls or .xlsx files was added to CMAP3 v. 2.8.0, conforming to the MS Excel file conventions of that time (2007, 2010). Recently, it has been found that changes introduced in MS Excel 2013 and 2016 are not compatible with the CMAP3 importing (download) function. The CMAP3 exporting facilities operate normally. For technical reasons, CMAP3 cannot be modified in this respect, but the issue can be circumvented, the approach depending on available PC/software resources and how frequently the importing function will be used. One option is to temporarily make and use only for the importing tasks an older PC/laptop with CMAP3 and MS Excel 2010 (or older) installed, and copy both project files (.cmdb and .txt) to the working PC environment for the actual processing and analysis. Second, if one must use CMAP3 in a PC with MS Excel 2013 or 2016 installed, importing can be enabled by installing a specific MS application called AccessDatabaseEngine.exe. For downloading it, go first to: https://www.microsoft.com/en-us/download/details.aspx?id=23734. After downloading and saving the file, click on the file (NB: as Administrator) and follow the wizard instructions as usual. In some PCs this app may cause that the CMAP3 window becomes smaller after importing. This is harmless. The window can be resized and it will return to normal after restarting CMAP3. In some PCs (not all) the window change can be avoided by running CMAP3 in Windows XP SP3 compatibility mode (right-click CMAP3 application in its folder or desktop icon, select Properties/Compatibility). We apologize for the eventual inconvenience.
1) A CMAP3 project is set up as usual.

2) The researcher constructs the Concept Pool (in fixed CCM the concept list), and imports it as the project's Standard Term Vocabulary (STV) (see section 6.2). The imported list contains the STAGs and STERMs of the standard concepts, and, if necessary, the secondary language terms (STENG).

3) Using the imported concept pool/STV, a Concept Selection List (CSL) is created for each S in the project. Content wise, the CSLs thus equal the concept pool and will be similar for all Ss. The CSLs contain the pool's concepts (=STERMs) and their STAGs in STERM's alphabetical order (see example below). The researcher can vary/change this order by Excel before administering the CSLs.

4) After presenting CSLs to the Ss (for example, electronically or by an interviewer in situ), the completed CSLs, which will now contain the information which concepts each S selected (= their NLUs), the selected concepts are imported from the CSLs to the project's NLU database. Notably, using the fixed list method, the Ss' concepts/CSLs are all identical and can be copied, but also in this case all Ss must have their own NLUs imported into the NLU database before the next stage to create the correct NTAGs.

5) Pairwise comparison matrices (PCM) are created of each S's imported NLU sets. In the fixed list method, although the matrices/concepts are similar, the NLUs must have the correct NTAGs. Therefore, every S must have his own PCM also in the fixed list method. The noting of the Ss' causal links in the matrices/files can be done by the Ss themselves electronically or by an interviewer etc. In all cases, the result is a PCM for each S, which, when completed, is imported to the project's NCU database.

6) When all PCM data has been imported, the SCU and SNT data tables etc. can be generated as usual.

To illustrate the above process, CMAP3 setup installs also a simulated structured CCM project CCM_Case2 to augment the default project CCM_Case1. Also the STV-file and the CSL and PCM-files for S01 and S10 in CCM_Case2 will be installed for demonstration purposes.

### 5.4.1 Importing Standard Term Vocabulary (STV) (Concept Pool)

The standard term vocabulary/STV corresponds to the concept pool in hybrid/fixed-list CCM. The standard term/concept list must be in Excel-format for importing. Therefore, it may make sense to create in Excel, too (Figure 5.3). When importing the STV data/worksheet, following conventions should be observed:
The file name given to the workbook/sheet must indicate that it contains the STV and include the project name. A valid file name before the extension (xls, xlsx) is, as in the example project, e.g.: STV CCM_Case2.

The STV worksheet has (Figure 5.3) three columns. The first row must be reserved for column titles. Titles can vary, but STAG and STERM (and STENG) are practical options. The STAGs in the first column must consist of one capital letter A-Z (no special characters) and two digits 01-99 (e.g., O01, P06 etc.). The second column must contain a text the STV (pool) concepts. The third column (STENG) is reserved for the second STV language if the study uses it. If not, the third column can be left empty.

There is no limit to how many rows, in other words STAG/STERMs, there can be. Notably, there must be no data after the last STAG/TERM row – i.e., all rows under it must be empty.

The STV worksheet must be named DATA. However, there can be more than one worksheets in the same workbook file, but differently named (e.g., Notes).

The completed STV/concept pool, which resides in the STV worksheet at the outset, is imported into CMAP3 by the <Import STV> button in the NLU module. This opens a selection window for locating and opening the correct file (e.g., STV CCM_Case2.xls). CMAP3 reads its contents into the STV data table and displays them in the NLU module’s lower (STV) window. The STV/pool’s concepts can be edited as usual in CMAP3. If there are major changes, it may be more practical to first delete the current STV contents (Tools-menu/STV-delete) and to create a new STV/pool worksheet and import it again.

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5 The STENG terms in the default project's STV are in the original language (Finnish) for demonstration purposes. In a typical real study, the STERMs would probably use the original language of the data sources, the STENGs a common reporting language, typically English.
5.4.2 Importing NLUs by Concept Selection List (CSL).

CSLs concept lists in *MS Excel* worksheet format, from which the Ss select their personal subsets of concepts in the pool/hybrid CCM method. A CSL contains the pool/STV concepts and the STAG codes. CSLs are thus identical with the concept pool (=STV data table) and same for all Ss. Technically, the CSLs are constructed by the <Create CLS-command> in the NLU module. This opens MS Excel and a CSL worksheet as shown in Figure 5.4 (example is based on CCM_Case2.xls).

In a CSL, three columns are obligatory and in this order: STAG (corresponding to the pool/STV concepts’ STAGs); NLU (corresponding to the STVs’ STERMs); and a 0/1 column (for the Ss to mark their concept selections by entering a 1 (= text, NOT a number in Excel) replacing the default zero). The column titles are created automatically by the <Create CLS> command. The CSL main worksheet *must* be named *DATA* as shown in Figure 5.4. If necessary, there can be a second worksheet called, for instance, *Guide*, to give instructions to the Ss about how many concepts can be selected, etc.

![Worksheet for eliciting and downloading a CSL](image-url)
For correctly importing each S's CSL (= NLUs) into CMAP3, the CSL file name must have that S's signifier (e.g., S01) and letters NLU - in this order. It also makes informative sense to link the saved CSL file and the project. A valid and informative file name would be, e.g., S01 NLU CCM_Case2.xls.

To import an S's CSL, <Import NLU> command is used in the NLU module. This opens a window for first locating the correct file and to open/import it. CMAP3 then downloads the respective NLUs (= that S's selected concepts) and automatically creates the appropriate NLUs with the NTAGs and STAGs and displays the number of imported concepts. The procedure is repeated for all Ss. The importing order of Ss is free.

5.4.3 Importing Causal Links Data (NCUs) using PCMs

Structured (hybrid or fixed list) CCM studies operate usually with small (n = 7-15) sets of concept and can therefore use the worksheet method for importing causal links. For this purpose, the NCU data must exist in an MS Excel worksheet form as square matrices, which have the respective S's selected concepts (NLUs) as rows and columns (Figure 5.5).

![Figure 5.5  PCM for NCU Acquisition/Importing](image)

**Preparing PCMs.** CMAP3 creates a PCM (Pairwise Comparison Matrix) for each S automatically by the <Create S-matrix> command of the NLU module for each S at a time (Ss selected in the submenu window). This produces a MS Excel workbook containing two worksheets. The DATA worksheet contains that S's concepts (NLUs with NTAGs) arranged into a square matrix. A GUIDE worksheet will also be created.
Using it is not obligatory, but it may be useful for instructions, interviewer notes, etc. A PCM example (S01 NCU CCM_Case2.xls, Figure 5.5) is installed for demonstration and can be displayed using MS Excel. It has 10 concepts/NLUs. The causal links have been specified using +/- signs and W-values of 1, 2 or 3. As shown, the PCM diagonal cells are darker to indicate that they should remain blank.

Sometimes it may be useful to add row- and column counters to indicate for the Ss their Od and Id numbers for each concept and/or at least the total number of links entered. If used, the counter formulas must observe that the matrix cell entries must be text for CMAP3 to import. To prevent import problems, it is a good idea to remove eventual counter rows and columns before importing. If they must be preserved, the user should copy the worksheet contents and paste them into a separate workbook of third worksheet, obviously not named Data.

**PCM File name.** As in the case of CSLs, the individual PCMs' file name must contain the S number, NCU, and for information preferably the project’s name. A valid and practical PCM-file name is, e.g., *S01 NCU CCM_Case2.xls* as in the example case.

As in the case of CLSs, there are different ways of entering NCU data to the PCM-matrices (see *CCM Book 2015*). It is, for instance, also possible that the Ss inform about NCUs by freehand drawing and someone enters the causal links data to the PCMs afterwards.

For importing the NCU data contained in the PCMs, NCU Module's *<Import Links>* command is used. CMAP3 checks and alerts the user if the worksheet contains invalid entries, e.g., non-text entries in the matrix cells or cases where the CNTAG and the FNTAG (i.e., the cause and effect concept pair selected) are identical (although the diagonal cells are shaded to indicate that no data should be entered there). These will not be imported.

Using CMAP3, the imported CSLs and PCMs can contain different numbers of concepts. This would be the case if the researcher enters varying numbers of concepts from documents or the Ss are allowed to pick different numbers of concepts for their personal sets, although unusual in structured CCM. Consequently, also the corresponding PCMs will and can be of different size.

**5.4.4 Downloading Large Sets of NLUs (RDWS)**

Technically, a CSL worksheet, corresponding to a data source like an actor respondent or a document, can contain \( n \leq 1000 \) NLUs. This facilitates using CSL/NLU downloading as a general NLU entry technique for large numbers of NLUs. The above CSL structure and file naming conventions must obviously still be observed. This technique is useful in document-based CCM studies (DBC, see Laukkanen & Wang 2015,
Chapter 7.1) instead of manual transcription (RDS, see 5.1 above) and keyboard entry of NLUs, but equally applicable in interview-based studies. The choice depends largely on data type and personal preferences.

The principle of an RDWS is shown in Figure 5.6. The RDWSs replace RDSs and enable two things: (1) copy/pasting the NLUs from the RDWSs to the CSLs for NLU import, and (2), by containing the original causal link data, the subsequent NCU entry using the NCU module as explained in 5.2. The NLUs and the NCUs can be entered to the RDWS by keyboard or, for the NLUs, copy/pasted from digital sources such as pdf-documents. To carry out the first task (CSL), a CSL worksheet must be first created, with columns, worksheet name and file name as noted above (Figure 5.4). The STAG and the NLU columns are *copied* from the RDWS and *pasted* on the CSL worksheet. In this case, *all* NLUs in the CSL must be *selected* (i.e., the <0/1> column has only 1's). Each NLU must also have a *valid* STAG, meaning that the STAGs and the respective STERMs exist in the project's STV. If necessary, the STV/STAG system (and the coding) can be *tentative* and contain only some or even only one provisional standard term.

![Figure 5.6: A hypothetical example of an RDWS](image)

When CMAP3 imports the NLUs from an RDWS, it creates for each NLU an NTAG, preserving thereby the *same order* of NLUs as in the CSL. Notably, conforming to the original RDS technique, CMAP3 assumes that there are max 50 rows/page and creates the NTAGs accordingly. Should a CSL have more than 50
NLUs, the NTAGs will reflect this. For example, the first NLU’s NTAG in Figure 5.6 would be 050101 and the NLU on the worksheet’s row 54 have NTAG = 050201. To save time and keep order, it is a good idea to include in the RDWS cells MS Excel formulas\(^6\), which automatically create the correct S, page and row numbers so that the RDWS information and the future NTAGs will correspond to support the NCU entry.

Because of the large number of NLUs, the PCM technique (5.4.3) for noting/downloading the NCUs is not possible. The causal links data (NCUs) must be entered by the keyboard/mouse click method using the NCU module after the NLUs have been downloaded. To know which two NLUs are linked and form a causal pair, the information must be available in the Effect-Row-# column of the RDWS (or an RDS). For example, in Figure 5.6, the NLU on the worksheet row 4 is assumed to influence the NLUs on rows 2, 5 and 6, whereby the numbers correspond to the row numbers in the created NTAGs, not the worksheet rows. For entering the NCUs, the information can be obtained from the RDWS, opened in its window, or by using printed RDWSs. If the project needs specification of the NCUs such as for the influence direction +/- or weight, this data is added to the link/row number (e.g., -2, -2/3). This information is for NCU entry purposes only.

### 5.4.5 Ensuring Import File Compatibility

Occasionally, importing problems may occur when the MS Excel versions and/or the file formats involved in the process differ. This can be the case if an S uses a different MS Excel version from the one the researcher uses to create and import CSLs and PCMs. To solve/avoid such compatibility problems, it is recommended that before importing the data into CMAP3, the researcher first opens and saves the external CSL and PCM files with that MS Excel version and file format, which was used with CMAP3 and is known to work. There can be also compatibility issues that are related to the differences between newer and earlier versions of MS Excel. These have been discussed in the Technical Note in Footnote 4.

### 5.5 Deleting Data

CMAP3 has a special facility for deleting the contents of the raw data (NLU, NCU, STV) tables (Tools/NLU delete, NCU delete, STV delete). NLU and NCU data can be deleted completely or for each S separately. The benefit is that the user can correct erroneous S data without needing to delete or re-entering all data. It does not matter in this case whether the data was keyboard entered of CSL/PCM imported.

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\(^6\) The cell formulas in the RDWS (Figure 5.6) columns A-C are: A4/S=5; B4/P(age)=1; C4/R(ow)=1; A5: =A4; B5: =IF(C4<50;B4;B4+1) and C5: =IF(C4=50;1:C4+1). The formulas to cells A6:Cnn can be copied from A5:C5 to save entry, whereby nn = the last NLU row in the RDWS.
Before deleting data, it is important to take into account that the raw data tables' contents are connected to enable generating SCU/SNT output data tables. Therefore, to prevent conflicts when all NLU data table contents or individual NLU data are deleted, the respective NCU data must also be deleted but not the other way around. CMAP3 does this automatically. It also follows that when the STV data table's contents are deleted, NLU and also NCU data must and will be deleted. Thus, it is a good idea to think before acting and to ensure that there are up-to-date backup copies of the project's cmdb file before deleting anything.

As for the output data tables (SCU, SNT) and their contents it is not necessary to delete them specifically. They will/can be regenerated when necessary, for example, as a result of changes in the NLU, NCU and STV data table. Regenerating the data tables will replace their previous contents.

5.6 Exporting Data tables

As noted earlier, all CMAP3 data tables, which contain manually entered or imported data (NLU, NCU, STV) or have been generated either as permanent databases (SCU, SNT) or as temporary data tables (FM, DMF, Statistics, NLU/SNT Matrix) can be exported/uploaded from CMAP3 to MS Excel.

Uploading data tables is done by mouse clicking the respective module's and data window's <Export> button. This starts MS Excel and opens a worksheet, where the accessed data table's contents will be displayed in the same order they were displayed in CMAP3. E.g., the NLU data table can be displayed in STAG order (Figure 5.7). If a filter is used to select/display a specific set of data, only those data table contents that correspond to the defined filter will be exported. It should be noted that exporting observes/starts from the first displayed row in the respective module window. Therefore, it is important to see that the display is scrolled to the beginning of the data table to ensure that all data (filtered or unfiltered) will be exported. If an error occurs, it can be easily corrected by repeating the operation.
Figure 5.7 An Example of Worksheet Exporting the NLU Database

The facility of exporting data to MS Excel is useful as it provides functions and analysis options, which cannot be available in CMAP3 itself. To name some benefits, exporting enables printing the data tables as such or after editing by MS Excel. Second, browsing/sorting large data tables is more convenient using MS Excel because of the larger and adjustable workstation display and/or font sizes. Third, MS Excel offers many logical, numerical and statistical functions, which can be useful in the CCM data analysis.
6. Standardizing and Standard Term Vocabulary (STV)

In the CMAP3 approach, standardizing refers to coding operations, where the original concepts or word combinations (NLUs) of the Ss are mapped into a uniform common meaning space or standard concept system. Technically, NLUs are interpreted as same denoting with a given standard term (STEM), in other words as belonging to the same meaning category, which is represented (labelled) by the appropriate standard term. Standard terms constitute a CMAP3 project’s Standard Term Vocabulary (STV). In research terms, there are different objectives, principles and technical solutions and validation methods in CCM standardizing /coding. These are discussed in more detail in CCM Book 2015.

6.1 Why Standardizing (Coding)?

In general, standardizing is about converting the NLUs into a common standard terminology. For instance, as in the default project (CCM_Case1.cmdb), the Ss might use different languages when talking about same phenomena. Standardization, in this case literally translation from one language into a standard one (English), is a precondition for comparing the Ss’ causal beliefs and establishing their similarity/dissimilarity and and for aggregating the causal beliefs of individual Ss into cause map representations of collective group beliefs. Other grounds include elimination of redundant (in research terms) synonyms or an analytic need to compress the original NLUs into compact synthetic standard concepts.

Standardizing (coding) can be understood by examining the example project (CCM_Case1.cmdb), installed as default when setting up CMAP3. It can be seen that the key idea is to link the NLUs with an appropriate standard node term (SNT) by assigning the NLUs the respective STAG. In keyboard NLU entry this is done by selecting (clicking) the correct SNT in the STV window of the NLU module. This brings the respective STAG and STEM into the NLU window’s fields, from which they will be saved along with the entered NLU into the NLU database. When importing NLUs using the CSL technique, the concepts (NLUs) in the CSL already include a STAG (Figure 5.4), which will be imported into the NLU database with the NLU and enables bringing the respective STEM there, too.

When generating output data tables (SCU, SNT), CMAP3 uses the STAG information in the NLU database, interpreting NLUs with the same STAG as belonging to (=same-denoting with) that particular standard term.

The generation of the output data tables (SCU, SNT) requires that all NLUs have been standardized (= have a STAG). At the outset, CMAP3 checks for this and gives an alert if there are uncoded NLUs. Obviously, the checking cannot ensure that the coding also makes sense, i.e., that appropriate STAGs have been entered.
6.2 Standard Term Vocabulary (STV)

*Standard Term Vocabulary* (STV) is a key component of in CMAP3 based CCM. It enables standardizing the original concepts (NLU) corresponding to the role of a *coding scheme* in content analysis of documentary or narrative data. The objectives and principles of building STVs in CMAP3 CCM studies are discussed from a research perspective in more detail in *CCM Book 2015*.

Depending on the CCM approach, the STV can be created *a priori* and thus *preceding* data collection as in concept pool/hybrid CCM. In interview or document based studies the final STV can be usually built only after data acquisition. It requires usually an *iterative* and *inductive* process, which begins with a *provisional* STV to enable a tentative grouping (standardization) of the NLUs into larger rough SNT categories of NLUs. These will be more transparent to analyse content wise when successively iterating toward the final STV.

*STV entry*. An STV can be *entered by keyboard* using the NLU module (Figure 5.1) or it can be first created using MS Excel and *imported* as described in section 5.4.1. Combining both techniques is possible, too.

*Number of Standard Terms (STERM)*. Technically, there is no upper or lower limit to how many SNTs there can be in the STV database. As noted, the STV is often at first provisional and small, containing only some STAG/STERMs that are sufficient for a tentative coding simultaneously with entering the NLUs.

*Active/passive STERMs*. The STAG/STERMs in an STV need not be all active. For example, provisional standard terms used initially but not in the final coding can remain in the STV database. As long as the passive STERMs are not linked to any NLUs they will not influence the generated SCUs and SNTs.

6.3 NLU/SNT Matrix – Iterative STV Development

The *NLU/SNT-matrix* (Figure 6.1) is accessed from the Main Menu or by keyboard command <F9>. The module window displays all *standard node terms (SNT/STAG)* that exist in the *last generated* SCU and SNT database. The NLU/SNT Matrix has the following columns:

1. *STAG* and *SNT* columns for the active *Standard Node Terms*.
2. *n/S* column shows the *number of Ss* using a given STAG/SNT, i.e., Ss who had at least one NLU, which was coded with that STAG;
3. *NLU(M)* gives the *average number* of NLUs in the STAG/STERM category, i.e., the sum of all NLUs thus coded (*n/NLU*) divided by the number of user Ss.
4. *n/NLU* displays the *total number of NLUs* that were coded into the respective STAG/STERM category.
The total number of SNTs in the active project, as generated, is displayed under the window. The button <Enable Sortbar> opens a bar, where any column title can be mouse dragged to sort the displayed data in that order. The button <Export > brings the matrix contents to MS Excel, opening a worksheet which lists the contents in the displayed order. As noted earlier, exporting begins from the first displayed STAG/STERM row. Therefore, to include all matrix contents in the exported set, the first displayed row must be the first (or last) data row in the NLU/SNT Matrix database.

NLU/SNT Matrix is one of the temporary data tables, which are generated each time anew, based on the active project and the last generated SCU/SNT databases. If the user wants to preserve the displayed contents, the NLU/SNT matrix must be exported and saved as a workbook/sheet file.

NLU/SNT Matrix supports the iterative development of the project's STV and NLU coding/standardizing. Figure 6.1 displays the NLU/SNT data in the default demonstration project. In study cases with large original data, the NLU/SNT matrix helps pinpoint, for instance, exceptionally large NLU/STAG/SNT categories that can indicate problems of consistency and very small categories/SNTs, which are idiosyncratic or shared by very few Ss. These can be examined closer and, if found necessary, recoded.
6.4 STAG Replacement

STAG Replacement is for batch recoding, where several NLUs must be assigned a specific new STAG. This is typically the case when very small SNT/NLU groups, detected by the NLU/SNT analysis, are moved into or combined with a larger or more relevant STAG/STERM category.

The STAG Replacement tool functions when the NLU Module is active. The tool is accessed by selecting <Tools/STAG Replacement> or by keyboard command <F12>. Both commands open a small window (Figure 6.2), which can be moved with the mouse.

![Figure 6.2 The STAG/STERM Replacement/recoding Tool](image)

In the upper field (<Old>), the currently active STERMs and STAGs are listed with the number of NLUs thus coded in parentheses. The STAG/STERM to be replaced is selected by mouse click. In the lower field (<New>), which accesses the project's STV, the user selects by mouse click the new STAG/STERM to replace the coding. To make the change the <Replace> button is clicked.

It should be noted that, when done, the STAG replacement cannot be recalled immediately. If an error happens, the respective NLUs must be recoded using the normal NLU Module procedures.

6.5 Parallel Projects and STVs

Depending on research needs, it is sometimes useful to set up one or more parallel projects. They can be created by the <Backup/Duplicate Project> in the Project Manager Module. The typical benefit of this is that it enables using the same most work intensive raw data (NLU, NCU) and/or an STV as a base for a new project with a different standardizing strategy/STV. For instance, using STAG Replacement, an initial low-
level detailed NLU standardizing can be quickly converted into a more general and encompassing higher level standard coding without rewriting or recoding using the normal standardizing routines.

6.6 Primary/Secondary STV Language (STERM/STENG)

The STV database provides for the option of storing in the standard vocabulary the SNTs in two languages, a primary and a secondary one, labelled respectively STERM and STENG in the NLU Module's STV window (Figure 5.1). The main benefit of this is that the generated output data (SCU, SNT) can be in either of the two entered languages.

Operatively, entering and using a secondary language (STENGs) is not obligatory. This depends on research needs mainly in terms of feedback validation of the coding and how the work is going to be published and in which form the generated output and causal maps will be used. A typical case for using secondary language and STENGs is when the Ss or documentary sources and thus the original data (NLUs) use native languages, which differ from the reporting standard language, as in the default project (CCM_Case1.cmdb).

If two STV languages are available in the STV database, the selection of the output language (STERMs or STENGs) is defined by the SCU and SNT databases' generation parameters as explained in section 7.1.
Standardizing assigns the original concepts (NLUs), which have been interpreted as having identical meanings or referents, into standard term categories. The process called generation uses the NLUs’ STAGs and creates of the NLU, NCU and STV databases two parallel databases of Standard Causal Units (SCUs) and Standard Node Terms (SNT). The source databases will not be altered in the process.

The process also identifies which S/Ss and how many Ss possess a given SCU and SNT, in other words, had correspondingly standardized NLU/NCUs in the original data. The S incidence information enables later distilling subsets of SCUs and SNTs, which belong to a given S, are shared by a specific number of Ss (TF = total frequency) or a specific Cluster if clusters have been defined. In addition, generation calculates for each SNT its Id, Od, and Td values and enters them into the SNT data table.

Generation can be started when the original data (= NLUs, NCU) has been entered and all NLUs have been standardized (at least provisionally). Starting generation is possible even if data for some S or Ss has not yet been entered. The process uses the STV, the NLU and the NCU databases, whereby the NCUs regulate the inclusion of NLUs (the respective SNTs) in the SNT database. An NLU not linked with at least one other NLU will not be observed by the process.

7.1 Generating Module and Parameters

Generation is started by mouse click in the Main Menu or by keyboard command <F5>. This opens the Generating Cause Map Units module (Figure 7.1), displaying the active project and the source data tables’ status. If they are in order, an OK comment is visible. If data for some Ss is missing, there is an alert. If there are NLUs with no STAGs or with STAGs that do not exist in the STV, an error message is issued. The errors must be located and corrected before proceeding. CMAP3 also checks that each S has at least one NCU. If NCUs are missing, an alert is given, but the generation can start based on the available data.
Before proceeding, the user must first define the generation parameters, some of which are obligatory, some optional, as follows:

**GTF.** The first compulsory parameter is the \(< GTF >\ >= >\) (Generating Total Frequency). The possible value range is \(1 - \text{max n/S}\) in the project. GTF regulates the degree of sharedness of the output SCUs and SNTs. If \(\text{GTF} \geq 1\), the SCU and SNT databases (SNTs depend on the generated SCUs) will contain all standardized data, including those possessed by a single S. In CCM studies interested mainly in shared concepts/beliefs, using a higher GTF will exclude idiosyncratic or less shared SCUs and SNTs, which may be considered outliers in research terms.

**S-number.** The second parameter is the \(<S\text{-number}>\). The default value is \(<\text{All}>\), whereby data for all Ss will be observed in the generation. It is possible to generate SCU/SNT data tables for a specified S only.

**CORE TF.** The third compulsory parameter is \(< \text{CORE TF} >= >\). Possible values are \(1 - \text{max n/S}\) (\(1 <= \text{CORE} <= \text{n/Ss}\)). The result can be seen in the CR columns of the SCU and SNT tables (Figure 7.4), which display a "1" for those SCUs and SNTs, which are shared at least by the respective number of Ss. From a research perspective, a Core value represents what is considered a typical, widely shared notion.
**CUT-W=**. If the research uses \( W \) (weight) values to specify the NCUs, the \(< \text{CUT-W=}>\) box and its tick box are used to control the processing of NCUs. \( \text{CUT-W} \) defines the lower threshold \( W \) value observed in the generation. If this option is not used, \( \text{CUT-W} \) has the value = 1 as the default for of \( W \) in NCU entry. If the box marked \(< \text{CUT-W}>\) is ticked (= default), all NCUs with \( W \) values equal to or higher than the \( W \) value defined by the researcher will be observed. For example, assuming the Ss were instructed to mark \( W = 2 \) for an important influence and \( W = 1 \) for a normal one, the user can generate SCU/SNT-output by entering \( W = 2 \). In this case only the former NCUs would be observed, producing less SCUs and a leaner SNT database and also influencing all other data tables based on the generated SCUs. In contrast, defining \( W = 1 \) would include all NCUs.

By removing the default tick of \( \geq \text{CUT-W} \) the user can define that only NCUs with a specific \( W \) value (including 0) are observed in the generated SCU/SNT data tables.

If \( W \) values are used to differentiate/signify different groups of Ss (see Section 5.3), by entering a given S group's signifier \( W \) number (and removing the tick), SCU and SNT data tables will be generated for that S grouping only. This influences also the FM, DM and Statistics data tables and C/D index values, which are based on the last generated SCU/SNT data tables.

In the case that NCUs have been entered with varying \( W \) values (0 \(<=\) \( W \) <=5), the \( W \) values in the SCU database and, e.g., in DM-SCU-browsing windows and exported worksheets will be calculated as arithmetic means, i.e., the sum of \( W \) values of the observed NCUs underlying that particular SCU divided by the number of NCUs. If \( W \) values are not used (i.e., entered NCUs have the default \( W = 1 \)), all SCUs will have a \( W \) value = 1. If the NCUs have different \( W \)/weights, the displayed output \( W \) values will vary 0\(<\ W\ <= \ 5.

The above parameters such as the GTF, CORE TF or \( W \) values can be changed and the generation process repeated as the user sees fit. In this way the impact of different values can be tested by regenerating the SCU and SNT output files and consequences of different or parallel solutions examined.

**STV language selection.** Depending on the case and the project's STV (see Section 6.6), a selectable option can be output language. In practice this means deciding should the SCU/SNT data tables use the primary language (STERMs), which is the default, or the secondary language (STENGs), if available in the STV.

At the outset, the generation module has two command buttons: \(<\text{Cancel}>\) (= return to the Project Manager) and \(<\text{Generate}>\). The duration of the process varies depending on source file size, defined parameters and the computer used. In typical cases the generation is a matter of tens of seconds, not minutes.
When the process is finished, the generation window changes (Figure 7.2). It displays the sizes of the generated SCU and SNT data tables and reports eventually deleted SCUs, resulting of precluding those SCUs, which assert that an SNT/NLU (as coded) influences itself directly. Clicking the <Finish> button closes the module and opens the SCU/SNT browsing window (Figure 7.2), which is accessible also from the Main Menu and by keyboard command <F6>.

### 7.2 Standard Causal Units (SCU)

The Browsing Cause Map Contents, here called the SCU/SNT module, opens automatically after the generation process is finished. The module can be accessed also from the Main Menu or by function key <F6>. As shown in Figure 7.3, the SC/SNT module has two windows; the upper Map Node Links-SCU-file displays the last generated SCU data table, the Map Nodes-SNT-file shows the standard node terms (SNTs) in the SCU data table.

The SCU window lists the SCUs ordered first alphabetically by the SCUs' CSTAGs of the CSTERMs, i.e., the "cause" or "antecedent" concepts of the standard causal units. The ESTAG and ESTERM columns list the respective “effects” or “consequences” of the preceding CSTERM. Clicking the column titles the order of display can be changed.
Figure 7.3  The SCU/SNT Module

The row immediately under the SCU window shows the total number of SCUs in the data table and the different available display filters. They are used to define which subsets of the generate SCU database will be displayed. Using filters affects only what is displayed and/or exported, not the generated data tables.

The column <NCU> shows the number of NCUs, which underlie (were subsumed into) each SCU. This may equal the TF, but can be higher if the respective NCUs are repeated by the Ss, typical in interview data. The repeated NCUs do not affect generated SCU data table, which include all distinct causal statements that exist in the NCU database as coded. The SCU data table shows all Ss, who have at least one corresponding NCU, and the total number (TF) of such Ss.

The column <D> (direction) displays the direction (+/-) sign of underlying NCUs and thus that of the respective SCU. In the unusual case that there are similarly coded NCUs, some of which direct (+) and some inverse (-), CMAP3 will generate two parallel corresponding SCUs, one direct, one inverse.
The \(<W>\) column displays the assigned weight of the original link in the NCU database. As explained in Section 7.1, the displayed W is calculated either as an average of the NCUs' original W values or a definite W value used as the generating filter.

The columns' C1 to C5 (C = cluster) value is = 1 if that SCU belongs to the respective Cluster/s as defined at the outset in the Project Manager. This applies also to the \(<CR>\) (Core), except that the CORE-TF value is defined at generation.

The \(<TF>\) (Total Frequency) column shows the number of Ss that share a given SCU. The max value of TF = n/S of the project. As noted, the GTF generation threshold can be set higher to exclude outlier or more unusual SCUs. In this case the SCU data table will usually be much smaller, which will be reflected also in the SNT and other data tables and numerical indicators, calculated based on the SCU database.

The S columns have a value = 1, if that particular S's owns the SCU, in other words, the S's NCU data contains an NCU, which was converted into that particular SCU (more accurately that NCUs' NLUs standardized into the respective SNTs).

When browsing the SCU data table, using the different filters enables focusing on different aspects and displaying selected contents of the data table. The filters include the Clusters (C1 – C5), the Core and the S number (default is all Ss) to show the SCUs possessed by a specific S or group of Ss. The \(<= TF <=\) filter uses the calculated total frequency (TF), i.e., number of Ss who possess a given SCU. It is possible to display SCUs using a minimum or a maximum TF value. Furthermore, to make the selection narrower, different filters can be combined by selecting another filter without clearing the previous one.

**Reciprocal SCUs (RSCU).** The \(< RSCU >\) button activates a filter, which enables identifying and displaying reciprocal or two-way SCUs in the database. A reciprocal standard causal unit (RSCU) means an SCU pair, where one SCU is of the type A ➔ B, the other SCU correspondingly B ➔ A. In other words the RSCU indicates a mutual influence relationship, where the respective SNTs (based on the underlying standardized NLUs) appear both as a cause and as a consequence of each other. The grounds and research implications of RSCUs are discussed in *CCM Book 2015*.

The defined filters are deactivated by clicking the \(< Clear filter >\) button. If the SCU database is very large, returning to the original display of all SCUs unfiltered may take some time.

The \(< CXL-export >\) command button creates a cxl file of the displayed (filtered/unfiltered) SCU data table. Using the cxl-format, the accessed data table or its filtered sub contents can be imported into CmapTools to be displayed and edited as graphical causal maps (Section 9.2).
7.3 Standard Node Terms (SNT)

The SCU/SNT module's lower window, titled Map Nodes SNT-file, displays the standard node terms (SNT) (Figure 7.3) in the SCU database. The displayed SNTs, the S, C and Cr incidence information and the numerical indicators are based on the generated SCU data table and will thus also reflect the parameters defined at generation.

The SNT window's first columns show the SNTs' STAG and STERM. TF displays the number of Ss, who possessed the SNT as a preceding or a consequence concept in the SCU data table. The columns ID (indegree) and OD (outdegree) display the number of causal links (in a graphical cause map, the arrows) that, respectively, come into a cause map node (SNT) or flow from an SNT node. TD (total degree) is the sum of ID+ OD (For the traditional research uses of Id/Od/Td values (see CCM Book 2015).

If the project has predefined clusters (C1–C5), their and the Core (CR) incidence are indicated by a <1> in the respective column. When a given S possesses an SNT, this is indicated by a <1> in that S's columns.

As usual, clicking the column titles, the user can sort the SNTs according to any of above dimensions.

The SNT window provides three filters. The first is used to display the SNTs of a specific Cluster or the Core. The second filter will display the SNTs of a specific S. Third, different TF values and upper and lower TF limits can be used. The defined filters are deactivated by clicking the <Clear filter> button.

The SCU and SNT databases and displays are independent of each other. This means that the SNTs in a SCU set displayed using a specific filter will not be displayed correspondingly in the SNT window and using the same filter in the SCU and SNT windows does not necessarily produce compatible results.

As usual, the displayed (filtered or unfiltered) SNTs can be exported by clicking the <Export> button. This opens MS Excel and a workbook/sheet. In this way the SNT data table's contents can be analysed using MS Excel's sorting tools and calculating or logical functions and formatted for printing.
8. CMAP3 Analysis Tools

The logic and goals of CCM analysis vary reflecting the different theoretical underpinnings, methodological approaches and the specific research or pragmatic objectives of each CCM project. These issues are discussed in some detail in CCM Book 2015. In general, CCM analysis focuses either on the substantive SCU/SNT contents (causal maps) representing the Ss’ knowledge/belief systems or emphasizes the structural characteristics the resulting causal maps such as density or different SNT types. In the former case, using visual analysis and graphic causal maps is typical, in the latter CCM analysis is largely based on quantitative indicators, which can be calculated using the SCU/SNT databases. CMAP3 supports both the more visual and the more quantitative, indicator based analytic approaches in CCM studies.

8.1 Focal Maps

A Focal Map (FM) consists of SNTs, which are directly causally linked to the selected focal SNT on the cause or effect side according to the last generated SCU database. The tool Focal Map Browser (Figure 8.1) is accessible by the Main Menu or <F7>. Its idea is to enable the user a virtual visual browsing and a selective content analysis of the last generated SCU database.

The FM Browser has two windows: A: Preceding Nodes – “Causes” and B: Linked Nodes – “Effects”. An SNT selection facility is located in the FM Module’s middle right side, where all SNTs in the last generated SCU database can be displayed by mouse scrolling. To define/produce a FM, the user selects by mouse click an SNT. The selected SNT will appear in the middle of the FM Module. The upper window displays the SNTs that precede the selected SNT (its "cause SNTs"); the lower window the consequent SNTs (its "effect SNTs") in the SCU database. Together, the displayed SNTs constitute the Focal Map.

It can be seen that the FM Browser can be used like a “magnifying glass” to study an imaginary large cause map, which corresponds to the generated SCU database. By successively selecting new and different SNTs as the focal phenomenon the causal map's different areas and subsystems can be examined.

The usual filters (Core/Cluster, S/all) and different lower or upper limits for the TF value can be applied when displaying the Focal Map. The displayed (filtered/unfiltered) Focal Map be exported and opened as a worksheet in MS Excel. Because the FM set is a transitory database, it must be exported if it is necessary to save some particular FM contents or to print a FM.
As discussed in Section 9 below, the FMs can also be exported in xl format to be then imported into CmapTools for displaying and editing as a visual causal map. In addition, the FM's SNTs can be copy/pasted using Windows Clipboard facility into another application like MS PowerPoint for drawing. In this case the FM will be transferred as text, the two windows’ contents separated.

8.2 Domain Maps

The Domain Map Browser (Figure 8.2) functions similarly as the FM Browser, but selects and displays a larger subset of causally interlinked SCUs from the SCU database. These SCU sets are called Domain Maps.

There are three DM types. In a full DM (DM-F), which is the default, CMAP3 first generates around the selected seed SNT a subset of SCUs corresponding to a FM. The cause side SCUs are shown in blue, the effect SCUs in green. It then adds to this FM base the “causes of the FM’s causes“ (light blue) and the “effects of the FM’s effects” (light green). The other DMs are narrower; the DM-C option adding only the cause side component and the DM-E alternative only the effect side components to the FM base.
To generate a DM, the user selects first the *DM type* (DM-F, DM-C, DM-E), and defines the relevant seed SNT concept (from the SNT list) around which the DM will be constructed. The DM Module's upper window displays the SCUs that constitute the DM as defined, the lower window the SNTs that are included in the DM's SCUs.

As usual, the DM/SCUs can be filtered (*C, Core, S/all, TF*). Notably, the SNTs displayed in the DM Module correspond to the SCUs displayed in the SCU window. This is because the tool creates an independent temporary SCU set of the full last generated SCU database. Depending on the base data and used filter, it can happen that some of the displayed SNTs appear separate, not connected to the other SNTs.

![Figure 8.2 Domain Map (DM) Browser](image)

The DMs' main function is to represent and to analyse large SCU databases / causal map systems, which are difficult or meaningless to access and display as a whole. The seed SNT selected is in this case usually a representative or key phenomenon or factor in the domain or causal system. Using DMs (and FMs) enables focusing on factors that are considered relevant or potentially interesting.

When creating DMs of large SCU databases (> 1000 SCUs) and/or when using highly central seed SNTs (i.e., SNTs having a high $T_d$ value), the DM and especially DM-Fs will contain a large number of SCUs.
Processing them using with filters may cause delays as the application must create and recreate the SCU and the SNT sets when updating their displays. This obviously depends also on the computer's capacity.

As the FMs, the generated DMs (filtered or unfiltered) can be exported to create a workbook file as cdl files to be created and analysed as visual causal maps using CmapTools (see Section 9.2). As noted, this may be an important element when reporting and analysing the results of CCM studies.

Depending on research needs and the database, an alternative to using DMs can be to generate the SCU database using a high GTF value. This will exclude the idiosyncratic or unusual SCUs and SNTs, producing SCU subsets and eventually exportable causal maps that are better focused on some key domains or issues and/or represent the typical characteristics of the Ss' belief patterns.

As the FMs, DMs too are always generated anew as temporary data tables based on the active project's recent SCU database. To save or print the contents of a displayed DM, they must be exported and saved as a workbook/sheet file.

8.3 Statistics Module

To support the quantitative cause map analysis, CMAP3 has the Statistics C/D Index module. It can be started by mouse click in the Main Menu or by keyboard command <F9>. This tool calculates a set of causal map indicators, which are in two temporary databases and displayed in two windows (Figure 8.3).

8.3.1 Project Statistics

The upper window (Project Statistics) summarizes the active NLU/NCU and SCU/SNT data tables' contents numerically and displays some indicators. The lower window (C/D Index) displays in matrix form a measure of the individual Ss' or Clusters' SCUs' or SNTs' mutual similarity (overlapping). All measures or indicators will be calculated based on the last generated SCU and SNT data tables and each time anew when the Statistics module is accessed. If the displayed numerical data must be preserved, the contents of the respective window must be exported and saved as a workbook file. Printing the data also requires exporting.

Figure 8.3 shows data of the default CCM_Case1 project. The Project Statistics window first rows display information about the Standard Node Terms (SNT): the Total number, the numbers for each active Cluster (C1-C5), the Core (Cr), and for each S. On the row titled SNT-%-Total the Clusters', the Core's and the individual Ss' SNT numbers are presented compared with the SNT Total (in percentages). For instance, S01 possesses 47.83 % of all emerging SNTs. The row SNT-CR shows how many of the SNTs are core SNTs, in
other words, belong to the SCU set that meets the Core's criterion defined at generation. The SNT-%-CR row gives (in percentages) the share of C's or S’s core SNTs as compared to the respective unit's all SNTs.

Figure 8.3  Statistics & C/D Index Module

The SNT-Unique and SNT-Unique-% rows show the Ss' unique SNTs: the number of SNTs that only a single S has in the generated SNT data table, and the percentage of the Ss' unique SNTs compared to that S's all SNTs. Notably, uniqueness means now SNTs that belong to only one S. Thus, Cs or the Core can have no unique SNTs. If the GTF is $\geq 2$, there will be no unique SNTs (or SCUs).

The SCU indicator set/rows display similar numerical data as for the SNT, but for standardized causal units, SCUs according to the generated database. In addition, the upper window contains the following indicators:

Density indicates (in percentage) the relative degree of overlap of the generated SCUs with a theoretical cause map, where the project's all SNTs would be linked to all other SNTs (in one direction only: the calculation formula does not assume direct reciprocal links). For instance, in Figure 8.3, the theoretical
maximum of \( n/SCU = 253 = 23*(23-1)/2 \). The default project's overall SCU set's density is thus 17.0 (43/253*100) and that of S01 = 8.30 (21/253*100).

**SCU/SNT** row shows the average number of SCUs per SNT in the generated SCU data table. The SCU/SNT relationship is calculated for the Total and for each S. It could serve as a density indicator, too.

**NLU/SNT and NCU/SCU.** The Statistics window's bottom row displays the number of NLUs and NCU for each S and their sum (Total). CMAP3 calculates also the relationship measures **NLU/SNT** and **NCU/SCU**, i.e., the ratio of all NLUs and NCU to the number of SNTs and SCUs for each S, the Total column showing the mean of the S's respective values. **NLU/SNT** and **NCU/SCU** ratios are dependent on the project's level of standardizing (see CCM Book 2015). In the default case (Figure 8.3), the low NLU/SNT values (M= 1.06) indicate a practical similarity of NLUs and SNTs and thus a low level of standardizing. These indicators can be used to analyse the uniformity and compression effects of coding in the whole project and across Ss.

### 8.3.2 C/D-index

The C/D-index window displays in matrix form a measure indicating the project's S or Clusters' overlapping or mutual correspondence/distance in the last generated SCU and SNT databases, in other words, the degree to which a given S or C pair possesses the same SCUs or SNTs (Figure 8.2). The user can make CMAP3 calculate the C/D-matrix using either the SCUs or the SNTs as the base by mouse clicking the respective option. Typically, the SNT base produces higher proximity values reflecting the usually higher variance and SCU numbers in the SCU database.

The calculating formula is: \( C/D \text{index} = n_s/(n_s + n_u + n_l) \), where \( n_s \) = number of shared causal links (SCUs) or concepts (SNT) and \( n_u \) and \( n_l \) the numbers of unique causal links (SCUs) or concepts (SNT) owned by a given S or Cluster pair. Unique in the formula refers to uniqueness relative to the compared pair, in other words that the other S or C in the pair has not those SCUs or SNTs as generated. In the upper Statistics-window SNT/SCU uniqueness means that only a given single S owns some SNTs or SCUs, the other Ss not.

The C/D-index's value range is 0 <= 1. A value = 1.000 results if the causal maps (SCU sets) or SNT bases of the compared S/C pair are identical, i.e., fully overlapping. A value = 0.000 indicates that the S/C pair has no SCUs or SNTs in common and no overlapping in the generated SCU or SNT databases.

As usual, Statistics module data in either of the windows can be exported as displayed and opened in MS Excel as worksheets using the Export buttons for printing or later analysis. This has the benefit of available statistical measures and formulas of MS Excel such as Means and Standard deviations or the construction of specialized indicators based on the NLU, NCU, SNT and SCU numbers and their distribution. It is also
possible to export the /D-index data via MS Excel to statistical software like SPSS for further analysis such as Cluster analysis. The research uses of C/D index values and technical issues such as the impact of the type and level of standardizing and GTF values set at SCU/SNT generation are discussed in *CCM Book 2015*.
9. GRAPHIC CAUSAL MAPS FOR VISUAL ANALYSIS

Using graphic causal maps in addition to the data tables and numerical indicators enables a visual analysis and a systemic view of the target phenomena. As noted at the outset, CMAP3 has intentionally no integrated graphic functions as dedicated drawing applications can provide much more options and versatility compared to a necessarily limited incorporated facility. When using CMAP3, there are three main approaches to visual presentation and analysis of the standardized output.

9.1 Focal Map Module

The FM tool discussed above (Section 8.1, Figure 8.1) provides in a non-graphical (text, database) format a simple facility for viewing the generated SCUs. An FM displays a selected focal or seed SNT's most proximate cause and effect SNTs. By sequentially selecting different seed SNTs, any part of the SCU set (standardized causal map) can be viewed. The FM displays can be viewed filtered and the displayed FM contents copy/pasted to a Windows application such as MS PowerPoint or exported/imported into CmapTools and viewed and edited as a visual causal map (see below).

9.2 IHMC CmapTools

A practical method to produce visual causal maps is to use IHMC CmapTools in combination with CMAP3. This is a widely used free software application for concept/idea mapping, which can be downloaded in different languages. The main benefit is that CmapTools can read (import) CMAP3 SCU sets as cxl format files, and convert them directly into editable visual causal maps.

All CMAP3 tools that access the generated SCU database, i.e., the SCU browser and the FM and DM modules have a <CXL-export> button. Clicking it creates of the displayed (filtered/unfiltered) SCU set a CXL-file (.cxl) and opens the Windows file management tool for storing the cxl file in a definite folder and also naming it if necessary.

After starting CmapTools, importing the created file there is simple (<File/Import/Cmap from CXL file>). The cxl file can be also moved or copied by mouse directly to the CmapTools window. After importing, the SCU set appears as a rough cause map in the viewer. If there are many SNTs, they often overlap and must be moved and edited for a more meaningful and logical layout. In typical cases a useful first approximation is achieved by issuing the <Autolayout> command (Ctrl-L). In order to edit and format the cause map, the

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7 http://cmap.ihmc.us/download/ (accessed 04.06.17). The current version is IHMC CmapTools v. 6.02
concepts (SNTs) can be moved and the connecting arrows automatically follow. The concepts and arrows can be formatted, the text edited, annotations added, etc.

It has occurred that CmapTools may have problems in reading some letters/signs (e.g., ö, ä, ü) that have been used in the standard term vocabulary (STV) and would belong thus to the exported SCUs/SNTs. To avoid such problems, it is recommended to use only standard English language letters in the STV.

A causal map created in CmapTools can be saved and exported as different graphic files (e.g., jpg), which can be embedded into documents. A simple, practical method is to use a screen capture tool and copy the causal map displayed by CmapTools and embed it as a graphic file into, e.g., a MS Word document.

9.3 Using Drawing Applications

Publishing and reporting purposes often require creating larger and detailed graphic causal maps which may contain annotations and complex formatting. In this case using a dedicated drawing/presentation application such as MS Power Point or the drawing tools of MS Word is usually a necessary and also a better alternative. These applications offer more formatting options and the causal maps can be saved in more file formats or embedded into other documents. A practical feature when drawing causal maps, e.g., in MS Power Point, is to use text boxes for the cause map nodes (SNT) and to connect the arrows corresponding to the SCUs to the text boxes’ "hot" points. When the nodes move, the arrows remain connected and move with the SNTs.

When using a drawing application, the SNTs need not always be entered/written again by keyboard. Instead, using the FM Module, they can often be copy/pasted in Windows. The <Copy FM to Clipboard> command enables embedding the displayed FM set into the drawing page by copying it into a pre-created text box. The text box (containing first the FM) can be duplicated and the unnecessary SNTs deleted to finally have the SNTs each in its own text box. These can be formatted and connected with appropriate arrows to other SNTs. The copy/paste and duplication/editing process is repeated until the causal map is completed.
10. CONTACT AND FEEDBACK

CMAP3 is a *non-commercial* application developed as a research project of the Department of Business, University of Eastern Finland (UEF), Kuopio Campus. The project began in 2004/2005 and has created several gradually improved released versions of the software in addition to larger number of test versions. The project has been supported by the *Finnish Foundation of Economic Education* (Liikesivistysrahasto). The downloading and using the software and the support documents is free.

As a return service, the developers of CMAP3 would very much appreciate hearing of user comments and experiences, of CCM projects and of any questions and suggestions for improving CMAP3 or the default projects. Please send an email to mauri.laukkanen@uef.fi or to marko.heikkila@iki.fi.