**Introduction**

Based on the theory of mental models and graph theory, the computer-based and automated AKOVIA (Automated Knowledge Visualization and Assessment) tool uses (a) graphical representations such as knowledge maps or (b) natural language expressions to analyze cognitive processes in persons solving complex problems at single time points or multiple intervals over time. The in-depth analysis process generates quantitative measures and standardized graphical re-representations for qualitative analysis and feedback (Ifenthaler & Pirnay-Dummer, 2014; Pirnay-Dummer, 2010; Pirnay-Dummer, Ifenthaler, & Spector, 2010). AKOVIA produces seven measures for the knowledge-oriented comparison of graphical and natural language representations (see Table 1).

**TABLE 1** Description of the seven AKOVIA measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Type</th>
<th>Short description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface matching</td>
<td>Structural indicator</td>
<td>The surface matching compares the number of vertices within two graphs. It is a simple and easy way to calculate values for surface complexity.</td>
</tr>
<tr>
<td>Structural indicator</td>
<td>Graphical matching</td>
<td>The graphical matching compares the diameters of the spanning trees of the graphs, which is an indicator for the range of conceptual knowledge. It corresponds to structural matching as it is also a measure for structural complexity only.</td>
</tr>
<tr>
<td>Structural indicator</td>
<td>Structural matching</td>
<td>The structural matching compares the complete structures of two graphs without regard to their content. This measure is necessary for all hypotheses which make assumptions about general features of structure (e.g. assumptions which state that expert knowledge is structured differently from novice knowledge).</td>
</tr>
<tr>
<td>Structural indicator</td>
<td>Gamma matching</td>
<td>The gamma or density of vertices describes the quotient of terms per vertex within a graph. Since both graphs which connect every term with each other term (everything with everything) and graphs which only connect pairs of terms can be considered weak models, a medium density is expected for most good working models.</td>
</tr>
<tr>
<td>Structural indicator</td>
<td>Concept matching</td>
<td>Concept matching compares the sets of concepts (vertices) within a graph to determine the use of terms. This measure is especially important for different groups which operate in the same domain (e.g. use the same textbook). It determines differences in language use between the models.</td>
</tr>
<tr>
<td>Semantic indicator</td>
<td>Propositional matching [PPM]</td>
<td>The propositional matching value compares only fully identical propositions between two graphs. It is a good measure for quantifying semantic similarity between two graphs.</td>
</tr>
<tr>
<td>Semantic indicator</td>
<td>Balanced semantic matching</td>
<td>The balanced semantic matching is the quotient of propositional matching and concept matching. Especially when both indices are being interpreted, balanced propositional matching should be preferred over propositional matching.</td>
</tr>
</tbody>
</table>


Login screen for registered users

Registration screen
Successful login screen – navigation bar including user options

Upload screen – choose ZIP file from your local computer

Successful upload screen – including assigned ticket number for all enquires
Active projects screen – information about validation and analysis progress

<table>
<thead>
<tr>
<th>Ticket</th>
<th>Time of upload</th>
<th>Time of validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>h7J86LGKXXMSs3450E</td>
<td>17.09.2013 - 04:27</td>
<td>17.09.2013 - 06:20</td>
</tr>
</tbody>
</table>

Validation

The following projects wait for validation by the system. This will be done within the hour.

<table>
<thead>
<tr>
<th>Ticket</th>
<th>Time of upload</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nJ0YTS9D2CSv16MF</td>
<td>17.09.2013 - 06:33</td>
</tr>
</tbody>
</table>

Available downloads screen – click on ticket hyperlink to start the download of the finalized analysis

<table>
<thead>
<tr>
<th>Ticket</th>
<th>Time of upload</th>
<th>Time of validation</th>
<th>Time processed</th>
<th>Download valid until</th>
</tr>
</thead>
</table>
Listform data input (e.g., knowledge map)

You require a spreadsheet template (listform_en.xls) including two sheets (see below): (1) “models” and (2) “meta”. The “models” sheet contains the data of all knowledge maps in list form. The columns “ModelNr”, “C1”, and “C2” are mandatory; the column “weight” is optional. Do not rename the column headers.

- The column “ModelNr” identifies individual representations (e.g., concept maps). The example below shows four individual knowledge maps (ModelNr 1, 10, 11, 12).
- The columns “C1” and “C2” contain the concepts of the knowledge maps. Concepts in the same row are linked with each other, i.e., a proposition (concept-link-concept). The first row of ModelNr “1” includes the proposition “research-methodology”.
- The column “weight” can be used to lay weight on specific propositions (e.g., importance of these concepts).

![Models sheet](image1)

![Meta sheet](image2)
**Written text data input (e.g., written essay)**

You require a spreadsheet template (tmitocar.xls) including one sheet (see below): (1) “meta”. The “meta” sheet contains the data of all individual text files to be analyzed. The columns “ModelNr”, “language”, and “file” are mandatory. Do not rename the column headers.

- The column “ModelNr” identifies individual written texts (e.g., a student essay). The example below shows three individual texts (ModelNr 2, 21, 22).
- The column “language” identifies the language of the written texts: en = English; de = German.
- The column “file” represents the filename of the written text. Only .txt files are accepted.

![Spreadsheet Example](image)

In addition to the spreadsheet, you need to provide the txt-files containing individual texts with the identical file name as included in the spreadsheet “tmitocar.xls”.

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AKOVIA Documentation v0.2
Dr. Dirk Ifenthaler & Dr. Pablo Pirnay-Dümmer
Http://www.akovia.de/cgi-bin/aw/webakovia.pl
Analysis commands

The “akoviacommands.xls” template is required for scripting the analysis functions of AKOVIA. The “akovia” sheet contains the scripting commands, specifications and references to ModelNr. The columns “Command”, “Specifications”, and “Arguments” are mandatory. Do not rename the column headers.

- The column “Command” identifies the analysis function as follows:
  - visualize – produces a graphical representation
  - compare – one-by-one comparison analysis using the seven core measures of AKOVIA
  - xcompare – one-by-several comparison analysis using the seven core measures of AKOVIA
  - ganalyze – additional graph-based measures

- The column “Specifications” identifies sub-functions of the analysis commands as follows:
  - For visualize the sub-functions are (1) “PNG” which produces a simple graphical representation and (2) “Weight;PNG” which produces a weighted graphical representation (this can be applied for written texts only)
  - For compare and xcompare the sub-function is EVERY which will generate an output including all seven core measures of AKOVIA

- The column “Arguments” identifies the ModelNr (written texts or listform) to be analyzed. ModelNr can be separated by “;” of a range of ModelNr can be defined by “-“.
ZIP-file to be uploaded

In order to start an AKOVIA analysis, a ZIP-file including all required files needs to be uploaded on the “UPLOAD screen” (see example below). After a successful upload, AKOVIA generates a ticket and sends an email to the user. AKOVIA validates the ZIP-file and sends another email to the user, confirming the correctness of the ZIP-file or identifying missing information in the ZIP-file. No individual files can be uploaded. AKOVIA only accepts XLS-file format (no XLSX or other file format).

Example of ZIP-file including the files from the examples above
ZIP-file containing AKOVIA analysis results

After the AKOVIA analysis is finished, another email is automatically sent to the user. After login to the AKOVIA tool, the user can download a ZIP-file containing the quantitative measures (compare and analyze – see Table 1 for interpretation) as well as qualitative graphical outputs (see below).