Albert-Ludwigs-Universität Freiburg
Department for Cognition, Action, and Sustainability

Thesis submitted in partial fulfillment of the requirements for the degree of
Master of Science (Clinical Psychology, Neuro- and Rehabilitation Sciences)

Cognitive-Affective Mapping within the context of staircase and elevator use.
Evaluating a new method in empirical psychological research

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Abstract

Thagard’s (2010) method of Cognitive-Affective Mapping has barely been employed in empirical research, despite having considerable potential for data gathering in psychology, as shall be outlined in this thesis. The method was tested through employment in a German sample of psychology undergraduates (N = 11); results indicate high acceptability, subjective accuracy, and usability of the CAM method and confirm its ability to generate useful insight into psychological processes, specifically motivators for everyday behavior. Observed and reported user difficulties with the method are discussed and recommendations are made regarding future adaptation of CAM for use in empirical psychological research.

Keywords: cognitive maps, cognitive-affective mapping, research methods, decision making, mixed methods, intervention design
Applied psychology is often a science of interventions: Fields such as clinical psychology, environmental psychology, educational psychology, and organizational psychology all include the design, implementation, evaluation and improvement of interventions aiming to change individual behavior. In good intervention design, theories from more basic research fields like social psychology, general psychology, and biopsychology are applied to specific real-world contexts (Michie, Johnston, Francis, Hardeman, & Eccles, 2008). This by necessity requires that abstract classes of psychological phenomena (for example, goals) be filled in with elements of these classes relevant for the specific context at hand (for example, the goal to lose weight), which first need to be identified. Although it is often recommended that the information needed for this specification be taken from the literature (Moore & Boldero, 2017), small-scale empirical studies may also be employed as generative research to help define the problem and tailor interventions to the target group. Qualitative research has great merit in this area and can reveal influencing factors on existing behavior as well as available resources for behavior change (Nastasi & Schensul, 2005).

In this paper, I will suggest the use of a new method, Cognitive-Affective Mapping (CAM), in this initial phase of intervention design. CAM was developed by philosopher Thagard (2010) as an extension of his coherence theory of thought and action (Thagard, 2000) and has mostly been applied in and promoted for conflict research and management (Findlay & Thagard, 2011; Homer-Dixon, Milkoreit, Mock, Schröder, & Thagard, 2014). It combines features of qualitative and quantitative methods. The end products created with it, called Cognitive-Affective Maps (CAMs), are visuo-spatial representations of the complex network of associations within people’s minds; critically, both the cognitive and affective structures of these networks are visualized. When used in conflict management, the cognitive-affective structure of each of the parties in conflict is usually mapped and the two (or, potentially, more) CAMs are then compared to identify core conflicts as well as similarities and leverage points for “conceptual intervention” (Homer-Dixon et al., 2014) that might be helpful in
creating a compromise or consensus (Thagard, 2010). Applied to intervention design, I propose that instead the cognitive-affective structure of members of the target population be mapped and leverage points be identified which might be used to facilitate behavior change.

CAMs follow a set of fairly simple rules: Cognitive concepts (which can be goals, actions, events, people, or ideas; Thagard, 2010) are represented as text within shapes; each such shape is called a node. Four types of shapes exist. They each signify one of four types of emotional valence which a concept can have. When color is available, valence is additionally signaled through colors. In this way, (red) hexagons denote negative affect; (green) ovals denote positive affect; (yellow) rectangles denote neutral or no affect; and (purple) ovals nested within hexagons denote ambivalent affect, which means that the concept evokes both positive and negative emotions. Each node is lined by a border, which varies in thickness depending on the intensity of the respective concept’s emotional valence (with thicker borders denoting greater intensity). Finally, associations between concepts are represented by lines which connect their respective nodes; these lines also vary in thickness depending on the strength of the association (with thicker lines denoting stronger associations). There are two types of lines. Solid lines denote supportive associations, meaning that the associated concepts are connected in a logically positive way: For example, they are proportional to one another (the more A, the more B) or one logically implies the other (if A then B). Dashed lines denote conflictive associations, meaning that the associated concepts are connected in a logically negative way: For example, they are indirectly proportional to one another (the more A, the less B) or mutually exclusive (if A then not B).

Because motivation is closely tied to emotion (Scheffer & Heckhausen, 2010), CAMs’ dimension of affect provides a valuable advantage over other forms of affect-free cognitive maps (such as mind maps or concept maps; Eppler, 2006) when motivation is the focus of interest, as is the case in generative research for intervention design. CAMs also provide more explicit information on this affective dimension as well as on the exact nature of
the relationships between concepts than do interviews, which are a common qualitative method recommended for intervention-informing research (Nastasi & Schensul, 2005). In past research, CAMs have sometimes been used to summarize data gained from qualitative interviews (Milkoreit, 2013; Wolfe, 2012), but I argue that research subjects – for example, members of the target population for an intervention – might as well be instructed in the technique and asked to map their own cognitive-affective structures. CAM would thus advance from a method for summarizing data to an independent method for data collection, which would have significant advantages over interviewing: less effort on the part of the researcher (no transcription, easily discernable units of information), greater control on the part of the participants (who have time to think twice about what to write, and are able to verify the immediate results of the mapping process), the capacity to represent information in a non-linear way (useful especially for information with a high degree of interconnectedness), potentially less bias due to social desirability (according to the results of Richman, Weisband, Kiesler, and Drasgow, 1999, face-to-face interviews are more distorted by social desirability bias than paper-and-pencil measures), and clear visual illustration of results.

The aim of this paper is therefore to develop and test a paradigm (including instruction materials, experiment design, and a method of data analysis) for applying CAM to an exemplary empirical-psychological research context as a direct data collection method. If useful insights into this exemplary research question can be generated using the suggested paradigm, this confirms the applicability of CAM to such contexts. Specifically, I investigate (a) whether CAM can generate useful leverage points for the planning of a behavior change intervention; (b) whether undergraduate psychology students (a frequently sampled demographic in psychological research; Arnett, 2008) can learn to visualize their own thoughts and affect using CAM within a single session; and (c) how well psychology undergraduates, in their roles as study participants, accept CAM as a research method. I expect positive answers to all the above questions. Finally, (d) I propose suggestions for
adaption of the CAM method to the demands of empirical psychological research based on
the user experiences of participants.

As an exemplary research question, I seek to identify which factors motivate
psychology students to use the staircase or, conversely, the elevator, when moving up or down
between floors in a building. The results are of real-world interest: They form part of the
foundation for the planning of a behavior change intervention implemented at the
Psychological Institute of the Albert-Ludwigs-University Freiburg, which aims to promote
stair use over elevator use in order to reduce the Institute’s environmental impact (Henzel &
Koster, 2018). Although plenty of interventions targeting this pair of behaviors are
documented in the academic literature (Andersen, Franckowiak, Snyder, Bartlett, & Fontaine,
Olander & Eves, 2011; Swenson & Siegel, 2013), empirical investigations of motivating
factors are rare. The present study is thus also intended to contribute to the body of research
addressing influences on individual staircase versus elevator use (Adams & White, 2002;
Lewis, 2011) and thereby help to inform future interventions in other institutions.

Method

Sample

Undergraduate psychology students were recruited through an online tool which
allows students to sign up for experiments as a mandatory part of their curriculum. They each
received one hour of participant credit as well as a surprise gift (one LED lamp). Because all
participants were fluent German speakers, the experiment was carried out in German; all text
examples quoted below are verbatim translations of the original content.
Materials

I personally tested all participants in one of several identical computer labs made available by the Department for Cognition, Action, and Sustainability. Windows and shutters were closed, and artificial lighting was used. All participants but one used a Lenovo ideapad 710S-13ISK, and all used a computer mouse but no mousepad. They drew their CAMs using EMPATHICA (Thagard, 2010), an online tool developed specifically for this purpose. I recorded the interviews using the free version of the DaRecorder app (Version 2.8.H3DF; SoomSoft, 2016) on a Blackview BV6000 android phone, and questionnaires were administered using ESF Survey (Questback GmbH, 2017).

Cognitive-Affective Mapping

The participants drew their CAMs following the rules defined in Appendix A. These largely correspond to the original set of CAM rules proposed by Thagard (2010) and reported above, but they differ in some aspects, reflecting my attempt to adapt the CAM method to the context of empirical psychological research.

One such divergence between the two sets of rules is that in Thagard’s original version, two nodes which are both green or both red must not be connected by a dashed line, whereas two nodes of which one is green and the other is red must not be connected by a solid line. These rules, which have already been broken by other research teams (Findlay & Thagard, 2014; Homer-Dixon et al., 2014), were dropped in the present study so as to reduce presuppositions about participants’ cognitive-affective structures and find out whether such “invalid” links would be drawn by participants if not explicitly banned.

This goes hand in hand with a tweak to the definition of a conflictive link: Thagard originally stated that two concepts are conflictive “if feeling good about one makes you feel bad about the other” (Thagard, 2010), but during study preparation, this proved difficult to explain quickly to users, a core demand of methods in empirical psychological research. For
that reason, conflictive links were instead explained as links between concepts which are either logically or practically incompatible (either A or B) or which have an indirectly proportional relationship (the more A the less B) – thus matching Thagard’s (2010) definitions of conflicting actions and goals, but not conflicting concepts.

Finally, in the original version, the thickness of a node’s border indicates the degree of valence associated with it; in the present study, it instead indicated the subjective importance of the concept. This, too, was intended as a simplification of Thagard’s definitions, “degree of favoring and disfavoring” (Thagard, 2010) and “relative strength of the positive or negative value” (Findlay & Thagard, 2014), which I deemed too complicated for lay users. I assumed that those concepts which participants identify as important would be those which they feel strongly about.

Design

For clarity, a brief outline of the study design is given here before the procedure is detailed below. The 11 psychology students who participated were first trained in the CAM method. They then created a practice CAM and, subsequently, the CAM on the contextual influences on their staircase and elevator use; during this stage, I observed and documented their behavior. Next, I interviewed them about their experience and opinions of the CAM method. Finally, they completed a set of online questionnaires, which were largely dropped from analysis. The staircase-elevator CAMs were analyzed to identify individual motivators for staircase and elevator use, whereas interview and behavioral data were used to evaluate the CAM method.

Participants sat down before the computer, with me sitting at their left side. After informing them about their rights and obtaining written consent to their participation in the study, I explained to them the CAM method, using a printed visual example of a simple CAM (with only one central node) as well as printed descriptions of what each individual graphic
feature available means (Appendix A). This print-out remained visible throughout the experiment and I remained in the room, enabling participants to ask questions about the method at any time.

Once all initial questions were answered, each participant drew a tutorial CAM while I observed their behavior. Tutorial CAMs illustrated a topic unrelated to the research question\(^1\) which they were instructed to imagine as a personal choice (“Imagine that you’re invited to a party tonight; but you also have an exam coming up that you still need to study for. Now you have to decide what to do tonight. Please use the CAM method to visualize what comes to your mind.”)

The tutorial ended either after 10 minutes or as soon as participants stated that they were finished, provided that they had added at least 10 nodes of their own. I then looked over the finished CAM, asked questions wherever anything seemed unclear, pointed out methodological errors, and made corrections in cooperation with the participant. The goal here was to achieve maximum fit between the finished CAM and the participant’s intended meaning, not to influence the content of the CAM.

Next, I instructed the participants to draw another CAM (hereinafter referred to as the \textit{target CAM}), illustrating a choice between using the stairs or using the elevator to move between floors in a building. Again, they built on two pre-installed neutral nodes (labelled “taking the stairs”/”taking the elevator”), which they were again instructed not to delete or rewrite (though they could otherwise interact with them as before). This time, participants

\(^1\) For the first five participants, the tutorial CAM illustrated a choice between going to a party versus studying for an exam, but I later changed this to a choice between handing in an essay versus taking an oral exam for a grade because I discovered that the party-versus-studying example shared potential motivating factors (e.g. discipline, social norms) with taking the stairs versus taking the elevator and thus might influence the target CAM.
were not prompted to imagine a choosing situation. This second mapping phase lasted either for 15 minutes or until participants stated that they were finished. During it, I had my back turned to the computer to reduce participants’ impression of being watched; I used this time to discreetly protocol the behavior observed during the tutorial. Afterwards, I again looked over and discussed the finished CAM with the participant as before.

Participants were then interviewed using a semi-structured guideline (Appendix C); these interviews were recorded and lasted between roughly three and a half and fifteen minutes. Questions concerned participants’ experience using CAM, their opinion on the method, and their suggestions for its employment and improvement, and were partially modelled after the questions posed by Thagard (Thagard, 2014) to another student sample. Also, participants were given the opportunity to comment on my interpretation of their behavior during the tutorial, as documented in the behavior protocol.

Finally, participants completed a series of online questionnaires. These were largely dropped from analysis and thus are excluded from this paper; only demographic information (age, sex, semester) as well as one item measuring individual propensity for taking the stairs versus taking the elevator on a sliding scale (“Please indicate how often you have used the stairs/the elevator to move between floors in a building during the past week”) were analyzed.

When possible, I discreetly observed whether participants used the stairs or elevator as they left the floor after the experiment.

Analyses

CAMs were analyzed on two levels, referred to in the following text as level 1 and level 2. Level 1 encompasses those analyses concerning the stairs versus elevator example, which are intended (a) to answer the exemplary research question regarding motivations for staircase versus elevator use, (b) to serve as a suggestion for how to analyze individual CAMs, and (c) to demonstrate CAM’s usability in empirical psychological research. On level
2, I examined how participants employed the CAM method; this data, along with the interview and behavioral data, formed the corpus of evidence for further, multi-dimensional evaluation of the CAM method in the context of empirical psychological research.

Based on the audio recordings of the interviews, I filled out protocol sheets modelled after the interview guideline. Using these protocols, I aggregated the answers to each question across all participants and evaluated them in an explorative, qualitative manner. The behavioral information recorded in behavior protocols during each experiment was also aggregated across participants in a similar fashion; this data is reported only where relevant to the aspects of acceptability, usability, and accuracy of the CAM method.

**Results**

**Sample**

11 undergraduate psychology students (10 female, 1 male; all in their first through fifth semester of the psychology program) participated in the study. They were aged 19 to 24 years ($\mu = 20.73$).

**Staircase and Elevator Use**

**Use patterns.** Participants reported using the stairs rather than the elevator 28% to 100% of the time ($\mu = 85.55\%$). Seven participants used the stairs when leaving the floor on which the experiment took place. In the remaining four cases, behavior observation was not possible.

**Motivations for use.** At level 1, a qualitative analysis was carried out of all concepts which the participants had generated. In a first step, all concepts were transferred into a text-only list, which I and a colleague independently divided into thematic categories. I compared the two resulting sets of categories and combined them into a third set. In a second step, another colleague was given the same list of concepts as well as this third set of categories,
and both he and I sorted each concept into at least one of the categories therein. Again, I compared my colleague’s solution and my own in detail and combined them into a final version. Table 1 lists the 27 categories that emerged.

Quantifiable data from the target CAMs was entered manually into an Excel sheet. For each node, the sheet listed an identification number, its text, the participant who had produced it, its value (color), its importance (border thickness), its connectivity (number of links with other nodes), and two binary variables indicating the presence or absence of a direct link with each of the two neutral nodes that had been pre-installed by me at the beginning of the mapping phase (hereinafter referred to as starting nodes). I computed the strength of each node’s association with each starting node using a newly developed method: To determine the strength of the association between two nodes, all possible “paths” (i.e. ways of graphically moving from one node to the other via dashed or solid lines) of length 1 or 2 (i.e. involving no more than two lines and crossing no more than one intermediary node) between them were identified. The strength of the association between two nodes was estimated as the sum of the strengths of all paths between them. Path strengths were calculated based on the thickness of the lines forming the paths: The strength of a direct path followed from the thickness of the line representing it; the strength of an indirect path followed from the average thickness of the two lines forming it. Dashed lines were assigned negative “thickness values”, solid lines positive values. The thickest lines (both solid and dashed) received the absolute value of 3, and the second and third thickest lines correspondingly received absolute values of 2 and 1. Because EMPATHICA includes a seventh line type – a solid line thinner than any of the dashed lines – this was given the value of +0.5.

I could now aggregate CAM data by category to reveal each category’s absolute number of mentions; the number of participants who had mentioned it; the number of separate concepts mentioned per participant who had mentioned the category at all; the overall valence
associated with the category across all participants who had mentioned it (where such an overall valence was subjectively apparent); its average importance to participants (considering only those concepts with either positive or negative valence); its average connectivity; and its average computed association strength with each starting node. Table 1 reports these parameters for each category. They do not form an exhaustive list of all parameters which might be drawn from CAMs but represent a tentative suggestion for angles from which CAMs might be quantitatively analyzed to enrich researchers’ understanding of the qualitative data comprised in them and to facilitate the creation of summary CAMs as exemplified in Figure 1. The results displayed here can serve as a first impression of the range within which these parameters may fall.

Based on the statistics discussed above, I created a summarizing CAM (Figure 1). For simplicity, all computed associations are displayed in it as direct links, ignoring any other, indirect paths already existing between the same nodes; where such indirect paths exist between two nodes, the summary CAM thus overrepresents these nodes’ association. Line thickness was determined by rounding association strengths to the nearest available thickness value; associations with strengths between −0.5 and +0.25 (excluding the endpoints) were thus rounded to 0 and not represented in the CAM. This differential treatment of negative and positive values is due to the circumstance that the thinnest solid line currently available in EMPATHICA has no dashed equivalent, which means that positive associations can be graphically represented even when they are considerably weaker than the weakest representable negative association.
<table>
<thead>
<tr>
<th>Category</th>
<th>Example</th>
<th>Times mentioned</th>
<th>Number participants&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Overall valence&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Average importance&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Average connectivity</th>
<th>Average association with stairs</th>
<th>Average association with elevator</th>
<th>% concepts more associated with stairs than elevator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habit</td>
<td>&quot;Habit&quot;</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1.00</td>
<td>3.00</td>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Control</td>
<td>&quot;More control&quot;</td>
<td>2</td>
<td>2</td>
<td>+</td>
<td>2.00</td>
<td>1.50</td>
<td>0.50</td>
<td>-0.63</td>
<td>100</td>
</tr>
<tr>
<td>Fitness and looks</td>
<td>&quot;Working out&quot;</td>
<td>5</td>
<td>4</td>
<td>+</td>
<td>1.80</td>
<td>2.60</td>
<td>2.65</td>
<td>0.10</td>
<td>100</td>
</tr>
<tr>
<td>Slow/Takes time</td>
<td>&quot;Time consuming&quot;</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1.00</td>
<td>1.33</td>
<td>0.67</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Exertion</td>
<td>&quot;Exhausting&quot;</td>
<td>14</td>
<td>7</td>
<td>-</td>
<td>1.38</td>
<td>2.36</td>
<td>1.14</td>
<td>-0.52</td>
<td>100</td>
</tr>
<tr>
<td>High temperature</td>
<td>&quot;Warm&quot;</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2.00</td>
<td>0.25</td>
<td>-0.25</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Undefined influence of travel companions</td>
<td>&quot;With friends&quot;</td>
<td>2</td>
<td>1</td>
<td>&amp;</td>
<td>2.00</td>
<td>0.25</td>
<td>-0.25</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

<sup>a</sup>Number of participants who mentioned the category.  <sup>b</sup>+ denotes positive valence, - denotes negative valence, & denotes ambivalent valence, 0 denotes neutral valence, a blank space means that overall valence could not be determined.  <sup>c</sup>Only concepts with negative or positive valence were included in the computation of this parameter.
<table>
<thead>
<tr>
<th>Category</th>
<th>Example</th>
<th>Times mentioned</th>
<th>Number participants</th>
<th>Overall valence</th>
<th>Average importance</th>
<th>Average connectivity</th>
<th>Average association with stairs</th>
<th>Average association with elevator</th>
<th>% concepts more associated with stairs than elevator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health benefits</td>
<td>&quot;Good for health&quot;</td>
<td>12</td>
<td>6</td>
<td>+</td>
<td>1.70</td>
<td>2.92</td>
<td>1.00</td>
<td>-0.67</td>
<td>92</td>
</tr>
<tr>
<td>Environment protection</td>
<td>&quot;Easy on environment&quot;</td>
<td>7</td>
<td>3</td>
<td>+</td>
<td>2.00</td>
<td>3.86</td>
<td>0.46</td>
<td>-2.18</td>
<td>86</td>
</tr>
<tr>
<td>Being perceived positively by others</td>
<td>&quot;What others think&quot;</td>
<td>6</td>
<td>2</td>
<td>+</td>
<td>1.60</td>
<td>3.67</td>
<td>0.92</td>
<td>-2.08</td>
<td>83</td>
</tr>
<tr>
<td>Physical activity</td>
<td>&quot;Moving&quot;</td>
<td>6</td>
<td>4</td>
<td>+</td>
<td>2.40</td>
<td>2.67</td>
<td>1.17</td>
<td>-0.79</td>
<td>67</td>
</tr>
<tr>
<td>Technical risks</td>
<td>&quot;Elevator crash&quot;</td>
<td>3</td>
<td>2</td>
<td>-</td>
<td>1.67</td>
<td>2.33</td>
<td>1.17</td>
<td>0.83</td>
<td>67</td>
</tr>
<tr>
<td>Health risks</td>
<td>&quot;Falling&quot;</td>
<td>5</td>
<td>3</td>
<td>-</td>
<td>1.40</td>
<td>2.60</td>
<td>0.95</td>
<td>0.90</td>
<td>60</td>
</tr>
<tr>
<td>Sweating</td>
<td>&quot;Sweating&quot;</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>1.00</td>
<td>2.00</td>
<td>-0.25</td>
<td>-0.25</td>
<td>50</td>
</tr>
<tr>
<td>Concept of self</td>
<td>&quot;Concept of self&quot;</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>1.50</td>
<td>3.40</td>
<td>1.10</td>
<td>0.55</td>
<td>40</td>
</tr>
<tr>
<td>Social contact</td>
<td>&quot;Meeting people&quot;</td>
<td>8</td>
<td>4</td>
<td>+</td>
<td>1.20</td>
<td>2.50</td>
<td>0.28</td>
<td>1.09</td>
<td>38</td>
</tr>
<tr>
<td>Own influence on others</td>
<td>&quot;Ecological role model&quot;</td>
<td>3</td>
<td>1</td>
<td></td>
<td>1.67</td>
<td>3.33</td>
<td>0.92</td>
<td></td>
<td>33</td>
</tr>
<tr>
<td>Category</td>
<td>Example</td>
<td>Times mentioned</td>
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<td>% concepts more associated with stairs than elevator</td>
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<td>---------------------------</td>
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<td>----------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Elevator environment</td>
<td>&quot;Cramped&quot;</td>
<td>4</td>
<td>2</td>
<td>-</td>
<td>1.50</td>
<td>1.25</td>
<td>0.13</td>
<td>25a</td>
<td></td>
</tr>
<tr>
<td>Distance traveled</td>
<td>&quot;If many floors&quot;</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>3.00</td>
<td>0.19</td>
<td>1.25</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Fast/Saves time</td>
<td>&quot;Fast&quot;</td>
<td>10</td>
<td>9</td>
<td>+</td>
<td>1.38</td>
<td>2.00</td>
<td>0.50</td>
<td>0.85</td>
<td>20</td>
</tr>
<tr>
<td>Waiting</td>
<td>&quot;Annoying waiting time&quot;</td>
<td>6</td>
<td>5</td>
<td>-</td>
<td>1.67</td>
<td>2.17</td>
<td>-0.79</td>
<td>0.83</td>
<td>17</td>
</tr>
<tr>
<td>Electricity</td>
<td>&quot;Energy use&quot;</td>
<td>10</td>
<td>7</td>
<td>-</td>
<td>1.78</td>
<td>2.20</td>
<td>-0.60</td>
<td>1.45</td>
<td>10</td>
</tr>
<tr>
<td>Consideration for others</td>
<td>&quot;Grandparents&quot;</td>
<td>1</td>
<td>1</td>
<td>+</td>
<td>3.00</td>
<td>2.00</td>
<td>3.50</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Physical impairment</td>
<td>&quot;Not fit&quot;</td>
<td>8</td>
<td>5</td>
<td>+</td>
<td>1.33</td>
<td>2.38</td>
<td>-0.19</td>
<td>1.19</td>
<td>0</td>
</tr>
<tr>
<td>Laziness</td>
<td>&quot;Feeling lazy&quot;</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td>1.67</td>
<td>2.33</td>
<td>1.83</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Loads</td>
<td>&quot;Transporting a load&quot;</td>
<td>2</td>
<td>2</td>
<td>+</td>
<td>1.00</td>
<td>1.00</td>
<td>0.50</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Comfort</td>
<td>&quot;Comfortable&quot;</td>
<td>7</td>
<td>6</td>
<td>+</td>
<td>1.43</td>
<td>2.29</td>
<td>-0.64</td>
<td>2.00</td>
<td>0</td>
</tr>
</tbody>
</table>

*aComputationally, one node in this category ("cramped", see Appendix B10) is negatively associated with “taking the elevator”; this is a computation error arising from the calculation method in combination with the way in which this node is linked to other nodes. Content-wise, all concepts in this category relate exclusively to “taking the elevator”.*
Figure 1. Cognitive-Affective Map summarizing the students’ associations with taking the stairs versus taking the elevator. In addition to regular rules for CAM interpretation, particularly large nodes represent particularly frequently mentioned categories.
Associations between categories which both are not central concepts (stairs/elevator) were only computed where the presence of a connection seemed plausible upon qualitative examination\(^1\). Of these, those associations which could successfully be computed are displayed in Figure 1 (Health x Physical activity: 1.75; Health x Fitness and looks: 0.5; Exertion x Physical activity: 0.33; Comfort x Exertion: -0.5; Environment protection x Electricity: -1.38; Comfort and Laziness: +0.67). The pairs “Physical activity” and “Fitness and looks” as well as “Waiting” and “Slow/Takes time” never appeared in the same CAMs and thus could not be computed. The associations between “Waiting” and “Fast/Saves time” (-0.33), as well as “Health benefits” and “Health risks” (-0.25), were too weak for graphic representation.

**Cognitive-Affective Mapping as an Empirical Research Method**

**Individual differences in CAM construction.** At level 2, the same target CAM data as discussed above was aggregated instead by participant. For each participant, I calculated the number of nodes (in total and by valence) and number of links drawn, number of categories mentioned, average border thickness, average connectivity, average emotionality (relative share of positive, negative, and ambivalent concepts), and average ambivalence.\(^1\)

\(^1\) I computed inter-category associations based on a similar method as detailed above for category-starting node associations. However, only direct links were considered here because most category nodes connect to at least one of the starting nodes and thus automatically have indirect connections with all other categories associated with the same starting node, which clouds interpretation. For computation of inter-category associations, I first selected all CAMs which include at least one concept from each of the two categories under examination. Then, I identified all those pairs of concepts which (a) come from different categories and (b) are connected by direct links. To estimate inter-category associate strength, I averaged the strengths of these direct links across all such pairs.
(relative share of ambivalent and neutral concepts). I also calculated the number of nodes, number of links, and average connectivity for each tutorial CAM to form a basis for within-subject comparisons. Table 2 summarizes these statistics and reveals considerable inter-individual variance across all variables. Interestingly, there were substantial correlations between target and tutorial CAMs for both number of nodes \((r = .52)\) and number of links drawn \((r = .84)\).

In a purely qualitative and explorative attempt, I tried to visually identify structure types of CAMs. It is important to note that I did not analyze the CAMs in their original structure, but only after some “cleaning up” as recommended in the literature (Homer-Dixon et al., 2014): While keeping all parameters intact, I rearranged nodes and links in space with the goal of bringing the CAM into the neatest possible shape; this mainly involved “untangling” lines to keep them from crossing each other.

Four types were identified. Figure 2 displays typical examples of each, though hybrid forms also occurred. In CAMs of the “Back to Back” type, the two starting nodes are linked by a dashed line and most other nodes connect only to one or the other. The resulting CAMs appear split in two sides connected by a “bridge” in the center which embodies the opposing structure of the map. In the “Single Column” type, the starting nodes instead form the outer corners of the CAM and the other nodes are positioned between them. Many nodes connect to both starting nodes; one of these connections is often positive and the other negative, thus conveying the opposing structure. The two types labelled “Double Column” are similar to “Single Column” in that their starting nodes also form the corners of the CAMs. But the opposing structure is visualized here through the presence of opposite word pairs, of which each word connects positively to a different starting node (and not at all to the other). In CAMs of the type “Double Column Without Mediators”, the nodes in each such pair are
Table 2

Participant Parameters Regarding Target and Tutorial CAMs, Including Starting Nodes

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>μ</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target CAMs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nodes</td>
<td>11</td>
<td>14.82</td>
<td>21</td>
</tr>
<tr>
<td>Links</td>
<td>13</td>
<td>21.45</td>
<td>32</td>
</tr>
<tr>
<td>Categories</td>
<td>5</td>
<td>8.00</td>
<td>11</td>
</tr>
<tr>
<td>Green nodes</td>
<td>3</td>
<td>5.73</td>
<td>8</td>
</tr>
<tr>
<td>Red nodes</td>
<td>1</td>
<td>4.55</td>
<td>9</td>
</tr>
<tr>
<td>Yellow nodes</td>
<td>0</td>
<td>2.82</td>
<td>8</td>
</tr>
<tr>
<td>Purple nodes</td>
<td>0</td>
<td>1.73</td>
<td>4</td>
</tr>
<tr>
<td>Average importance&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.00</td>
<td>1.56</td>
<td>2.18</td>
</tr>
<tr>
<td>Average connectivity</td>
<td>2.00</td>
<td>2.93</td>
<td>4.31</td>
</tr>
<tr>
<td>Emotionality</td>
<td>53%</td>
<td>82%</td>
<td>100%</td>
</tr>
<tr>
<td>Ambivalence</td>
<td>0%</td>
<td>29%</td>
<td>71%</td>
</tr>
<tr>
<td><strong>Tutorial CAMs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nodes</td>
<td>8</td>
<td>12.90</td>
<td>18</td>
</tr>
<tr>
<td>Links</td>
<td>10</td>
<td>16.60</td>
<td>25</td>
</tr>
<tr>
<td>Average connectivity</td>
<td>2.00</td>
<td>2.64</td>
<td>4.50</td>
</tr>
</tbody>
</table>

<sup>c</sup>Only concepts with negative or positive valence were included in the computation of this parameter.
Figure 2. Typical examples of each proposed CAM type.
directly linked to each other by a dashed line, whereas in the only identified CAM of the type “Double Column With Mediators”, their connection is expressed indirectly through a third (usually neutral) node to which they are both linked.

Nine CAMs were assigned the type “Back to Back”, five were assigned “Single Column”, two were assigned “Double Column With Mediators” and one “Double Column Without Mediators”. Four CAMs did not fall neatly into one type (“Hybrid”). One tutorial CAM could not be assigned a type because it was only available in an unfinished stage due to technical errors during saving. CAM type was analyzed for all other CAMs (target and tutorial) and compared within subjects. For six out of those 10 participants for whom comparison was possible, tutorial and target CAM shared the same type.

16 out of 236 total connections drawn by participants violated the rule defined by Thagard (2010) that two nodes which are both red or both green must not be connected by a dashed line and a green and a red node must not be connected by a solid line.

Accuracy. All 11 participants acknowledged that their finished target CAM was a good representation of their own thoughts and feelings on the topic of taking the stairs versus taking the elevator. However, most also pointed out slight inaccuracies, such as the CAM including “too much” (because they do not normally think so much about why they take the stairs) or “too little” information (because not all situational factors can be included).

There was less need than expected for clarification in the post-mapping conversations, though I sought some clarification on almost every CAM and some minor errors were caught in this way that would otherwise have distorted the data somewhat.

Usability. Most participants said that they found the method easy to apply; the others had mixed feelings (for example, one said that it was harder in the beginning). Many named specific difficulties when prompted; these included confusion about negative links, about ambivalence, and about the definition of subjective importance.
Specifically, the issues with negative links reported by a few participants could be observed in several more who did not actively report them; for example, these links were mistakenly interpreted as “weak” connections or connections that “maybe” existed, and they were also sometimes forgotten and then added during the post-mapping conversation.

Almost all participants displayed confidence, autonomy and skill in interacting with EMPATHICA and drawing their CAMs, and they asked few questions during the mapping phase. Three finished their target CAMs before time had run out.

Acceptability. All participants said that learning the CAM method was interesting. Several also made other positive statements without being asked; for example, they said that they had fun using the method. When asked if there was anything they wanted to criticize about the method, many offered some criticism (such as the resulting CAM being ugly) or suggested improvements (such as including arrows to denote an asymmetrical influence of one concept on another), but there was little overlap between their critiques.

Nine participants said that they had personally profited in some way from drawing the target CAM. The most frequent benefit seemed to be a bringing to conscious attention of previously unconscious information. Without being asked, two participants stated that the process had sparked an intention in them to take the stairs more often. While many participants stated that they had changed their opinions on certain aspects of the CAM, these changes of mind occurred on a small scale, concerning links and the colors of particular nodes. Only about half of the participants found the CAM method useful for the stairs versus elevator example, but all were able to name other contexts in which it would be of use.

Upon receiving the offer, all participants asked to be informed about the study’s results; two also asked to receive their own CAMs via e-mail.
Discussion

The main purpose of this study was to find out whether CAM is applicable as a method for data gathering in individual-level psychological research. The results confirm that psychology students can quickly learn to use CAM and accept the method well. The successful identification of individual motivators to use either the staircase or the elevator further indicates that CAM data can yield scientific insight into individual decision-making, demonstrating the method’s usefulness for psychological research.

Motivations for Staircase and Elevator Use

The CAMs used in this study revealed 27 influencing factors on participants’ decision to use either the staircase or the elevator. These factors varied greatly in frequency of appearance. Several categories were only mentioned by one participant each; it is therefore likely that complete data saturation was not achieved, and if I had tested more participants, further categories would have emerged. However, the existing categories reflect a wide spectrum of factors and reveal multiple opportunities for designing effective interventions:

Health benefits, which have often been used as the basis of interventions to promote staircase use in the past (Andersen et al., 1998; Iversen et al., 2007; Kerr et al., 2000; Suri et al., 2014), have indeed emerged from the CAMs as an important motivator for this behavior, which confirms their potential to drive effective interventions. Other associations reported with similar frequency are centered around the intrinsic characteristics “physical exertion” and “comfort”, which due to their intrinsic nature do not make useful targets for interventions. Electricity and environment protection were also frequently mentioned. However, this might be an anomaly of the sample studied: A short time before this study, an environment-focused intervention had been carried out in the same building which aimed to reduce staircase use and involved a publicly displayed poster (Backmund, Henzel, & Koster, 2018). This finding should thus be treated with caution: Electricity and environment protection might only be
useful leverage points for interventions when they have previously been made salient as aspects of staircase versus elevator use.

One other notable leverage point for future interventions is the perceived speed of travel associated with each option. Almost all participants mentioned this aspect. However, participants were not unanimous regarding each option’s speediness, as Table 1 indicates: While slowness was associated exclusively with taking the stairs, fastness had substantial associations with both staircase and elevator use on the sample level. The individual CAMs provided in Appendix B illustrate that this ambiguity does not result from individual confusion. Instead, each participant had their own, usually unambiguous, belief about which mode of travel is faster, but these beliefs differed between individuals. It might be promising to first identify which option is in fact the faster one in a given building under a range of circumstances (such as variations in the number of floors traveled, traveling down versus traveling up, and whether the elevator is already in position or must first be requested). This information could then be made available to the building’s users to help them make more economic travel mode choices, hopefully leading habitual elevator users to use the stairs when this is the quicker route. Of course, this approach entails the risk of encouraging elevator use in habitual stair users in certain situations.

The influencing factors identified in the CAMs match those found in previous studies. Environmentalism, personal comfort, physical exertion, loads carried, needs of travel companions, time pressure (and the need to travel quickly which is implied therein), speed, and number of floors traveled all appear both in the CAMs and in Lewis's (2011) summary of the literature. Interestingly, while the data also largely match the influences identified by Adams and White (2002) in their interview study, two additional aspects found by Adam and White are missing from the CAMs evaluated here: direction of travel (whether one is traveling up or down) and the number of people on the stairs or in the elevator. In turn, the CAMs include aspects not mentioned by Adams and White (2002), such as waiting time,
control, social judgment, and electricity. Whether these differences are caused by the differing samples, buildings or methods of data collection is unclear.

It should be noted that the sample studied here exhibited a high propensity to use the stairs rather than the elevator, reflected in their reported and observed travel mode choices. It is therefore possible that the motivations reported are characteristic of “staircase users” and differ from those influencing “elevator users”. The leverage points identified here may thus be more useful for preventing occasional elevator use in people who generally use the stairs than for encouraging staircase use in people who generally use the elevator. Their generalizability hinges on the similarity of both sub-populations’ cognitive-affective structures surrounding the staircase versus elevator choice, which would require further research to determine.

**Evaluation of Cognitive-Affective Mapping in Empirical Research**

The substantial overlap between the insights gleaned from the CAMs and existing research justifies the conclusion that CAMs can be used effectively to investigate people’s motivations for engaging in clearly defined behaviors such as stair climbing, and that the results this method generates are comparable to those yielded by qualitative interviews. Further, as demonstrated above, CAMs can help to identify promising leverage points for interventions aiming to change behavior. These findings confirm the method’s utility for empirical psychological research and applied psychology, specifically in areas involving interventions such as clinical psychology, educational psychology, organizational psychology, and environmental psychology.

The data gathered from interviews and behavior observation further indicate that undergraduate psychology students are capable of learning how to employ the CAM method within roughly twenty minutes when the suggested sequence of instruction, tutorial, and post-mapping conversation is used. The students interviewed here agreed with the philosophy students in Thagard’s (2014) sample on finding CAMs useful in principle; they showed good
acceptance of the method, largely confirmed their CAMs’ accuracy in displaying their thoughts and feelings, and demonstrated considerable skill in using the method despite also offering criticism of it. These findings justify the conclusion that Cognitive-Affective Mapping can be used effectively and efficiently in empirical psychological research, at least in samples made up of psychology students, which translates to a large bulk of studies.

**Recommendations for Future Exploration and Development of CAM for Empirical Research**

Despite the utility of CAM confirmed by this study, several obstacles still exist which hinder the successful application of the method to empirical research.

First, individuals seem to draw CAMs in a variety of ways, differing not only in criteria like the number of nodes and links drawn or the degree of emotionality but also in essential structure. It remains to be seen whether the structural types proposed in this paper emerge again in future research; if so, this raises important questions both in terms of content and regarding data processing: Do different CAM types reflect different ways of thinking about an issue? Do individuals exhibit stable propensities for certain types over others, as tentatively suggested by the fact that target and tutorial types often matched in this study? Do different CAM types have different profiles across the statistical parameters suggested here for CAM analysis, and if so, how can this confounding factor be considered when reporting CAM data? Does the method described here for computing associations in CAMs lend itself less well to application to some structural types than others, and if so, how else can associations be computed in a way that does not discriminate between types?

Second, note that the calculation method outlined here is only a tentative and preliminary suggestion, which will require future improvement. While the method does yield good results for the most part, it fails to faithfully take into account all of the many ways, some very complex, in which concepts can be linked together within a CAM; as a result,
errors in computation occur which I presently have no solution for. Also, calculating the strengths of indirect paths as the averaged thickness values of all the lines forming them is not a practical solution if paths of lengths greater than 2 (which were excluded here) are included in the analysis: This would lead to strong associations emerging between concepts which have no apparent connection. Longer paths should therefore be mitigated in some way.

Third, for larger scale application in empirical research, a Cognitive-Affective Mapping tool is needed which is suited to the requirements of research. The current version of EMPATHICA could be made into such a tool by making only a few simple changes. First of all, a research-friendly mapping tool should output the exact values for line thickness, border thickness, and color into a data file; as long as all of these parameters must be read out manually, larger sample sizes than featured in this study provide a great challenge to manage. Also, this program could automatically calculate some or all of the parameters reported throughout this paper (as has already been suggested by Milkoreit, 2013), including association strengths, participant-centered statistics, and perhaps even category-centered statistics (upon receiving input about qualitatively derived categories). Even more basic, a function for copying and pasting CAMs would be very helpful for the creation of summarizing CAMs as well as for cleaning up participant CAMs or translating them for international publication while still retaining the originals.

On a more theoretical level, it must be clarified how many types of links should exist and how these should be treated; specifically, the thinnest solid line currently available in EMPATHICA, which has no dashed equivalent, must be clearly defined both for data processing and for instruction of participants. The addition of features not originally rooted in Thagard’s (2000) coherence theory of cognition and action might also be worth considering. Participants in this study repeatedly asked for or improvised ways to convey aspects not covered by current CAM features, such as conditionality or an influence of one concept on the relation between two other concepts; a simple commenting function, perhaps using grey or
blue text boxes, could help to communicate such participant needs and avoid misinterpretation of CAMs.

The rules governing which types of lines (dashed or solid) may be drawn between which types of nodes, which were not explicitly communicated in this study, were consequently violated by several participants. In each case, these violations transport relevant information about the logical relationships between concepts. For this reason, I suggest that these rules be dropped from CAM instructions when the method is applied to psychological research, in order to enable participants to express themselves as freely as possible.

Finally, although the participants involved in this study all received the same standardized instruction, they still interpreted some features in different ways (most notably, the dashed lines). It is thus crucial that sets of improved standardized instructions be devised and shared between researchers to enable comparable employment of the method across studies and foster a comprehensive and collectively understood grammar of CAM within the context of empirical research.

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Appendix A

Instruction materials (translated from German)

Figure A. Verbatim translation of the German instruction material explaining CAM rules.

Future instruction materials should include more information on the difference between dashed and solid lines, as well as connections between nodes that are both not the starting node(s).
Appendix B

Individual CAMs (untranslated German originals)

*Figure B1.* Cognitive-Affective Map generated by participant #1.
Figure B2. Cognitive-Affective Map generated by participant #2.
Figure B3. Cognitive-Affective Map generated by participant #3.
Figure B4. Cognitive-Affective Map generated by participant #4.
Figure B5. Cognitive-Affective Map generated by participant #5.
Figure B6. Cognitive-Affective Map generated by participant #6.
Figure B7. Cognitive-Affective Map generated by participant #7.
Figure B8. Cognitive-Affective Map generated by participant #8.
Figure B9. Cognitive-Affective Map generated by participant #9.
Figure B10. Cognitive-Affective Map generated by participant #10.
Figure B11. Cognitive-Affective Map generated by participant #11.
Appendix C

Interview Questions (translated from German)

Q1  How well does the finished CAM represent your thoughts and feelings on this matter?
Q2  Did you find it easy or difficult to draw this CAM?
Q3  Did you have any difficulties drawing the CAM and if so, what were they?
Q4  Was drawing this CAM at all useful to you?
Q5  Did you change your mind about any aspect(s) of the topic while drawing this CAM?
Q6  Was it interesting to learn this method?
Q7  Do you think that this method is useful to find out how people (other than you) think about this topic?
Q8  For which other topics do you think this method would be useful?
Q9  Is there anything you would like to criticize about the method or which you think would be better if it was different?
Erklärung

Ich versichere hiermit, dass ich die beiliegende Arbeit mit dem Thema:

**Cognitive-Affective Mapping within the context of staircase and elevator use.**

**Evaluating a new method in empirical psychological research**

selbständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt habe.

Die Stellen, die anderen Werken dem Wortlaut und dem Sinn nach entnommen sind, habe ich in jedem einzelnen Falle durch Angabe der Quelle, auch der benutzten Sekundärliteratur, als Entlehnung kenntlich gemacht.

Mir ist bekannt, dass die Prüfung für nicht bestanden erklärt wird und dass ich von der Wiederholungsprüfung ausgeschlossen werden kann, falls sich die Unwahrheit der abgegebenen Versicherung erweist.

Ich bin damit einverstanden, dass meine beiliegende Arbeit öffentlich einsehbar ist (Bibliothek) und der wissenschaftlichen Forschung zur Verfügung steht.

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