Understanding Computing Stereotypes with Self-Categorization Theory

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ABSTRACT
The partly completed study presented in this paper explores characteristics of *stereotypes in Computer Science.* The study describes student autobiographical essays about computing, analyzed with particular attention to the ways in which students use computing stereotypes. We describe how self-categorization theory, taken from the psychology stereotype literature, might explain the essays we see and discuss potential implications of self-categorization theory on CS Education in general.

Categories and Subject Descriptors
K.3.2 [**Computers and Education**]: Computer and Information Science Education – *Computer science education, Literacy, Self-assessment.*

General Terms
Experimentation, Human Factors.

Keywords
Stereotypes, CS, Computers and Society, CS Education Research, Pedagogy, Computer Biographies, Categorization, Group Identity.

1. INTRODUCTION
Students in Computer Science (CS) have to cope with negative stereotypes associated with the field. Previous research has shown that stereotypes are frequently mentioned when students consider reasons not to further their CS education [7, 13] . Bigger's [3] study of CS student retention shows evidence that students leaving CS had more negative stereotypes of computing careers then those who did not. We know that some students embrace stereotypical "nerd" behaviors but that many others distance themselves from them [10]. Some advocate improving the image of CS in order to improve retention [11]. However, an examination of the literature on stereotype psychology strongly suggests that attempting to change stereotypes is problematic [12]. Before CS educators attempt to change stereotypes, we should further consider the effect of stereotypes on thinking.

In the in-progress study presented in this paper, we analyze with regard to stereotypes a set of computer autobiographies written by students. The preliminary results are examined using self-categorization theory. This psychological theory describes how stereotypes are used to create individual identities and we present it in the second part of the article. The paper concludes with a discussion section and some potential implications of this theory to CS education and teaching.

2. EMPIRICAL STUDY
Even though stereotypes had not been the subject of our previous empirical studies [5, 6], we observed that students often mentioned computing stereotypes. In the current study, we reinvestigate empirical data with the focus on stereotypes. This data consists of students' autobiographical essays about computing experiences (computer biographies). We asked students to describe experiences about computing but otherwise the question was intentionally left open-ended in order to encourage the students to make their own decisions about what experiences were most significant.

"Stereotyping is the process of ascribing characteristics to people on the basis of their group membership." [9] We used this definition as we asked the following research questions:

1. Do students mention stereotypes, explicitly or implicitly, in their biographies?
2. What kinds of stereotypes do they mention?
3. Do they use stereotypes in order to explain their decisions, behavior, preferences, or interests with regard to computing and CS?

In the current study, we examine 271 biographies: 244 biographies were written by German university students, 27 biographies were written by US college seniors. In both samples, some of the students are CS majors and some are studying majoring in non-computing fields. For more information about data collecting see [5, 6]. Though students were not asked about stereotypes explicitly, considerable references to stereotypes occur in our autobiographies. This indicates how important stereotypes are to student's relationship with computing. The next section describes our analysis of the autobiographies' use of stereotypes.

2.1 Qualitative Content Analysis
Qualitative content analysis by Mayring is a methodology from qualitative social research used to analyze systematically textual data. "The main idea of the procedure is, to formulate a criterion of definition, derived from theoretical background and research question, which determines the aspects of the textual material taken into account. Following this criterion the material is worked through and categories are tentative and step by step deduced. Within a feedback loop those categories are revised, eventually reduced to main categories and checked in respect to their reliability." [8] This procedure can be divided into five consecutive steps in which a category system is developed. These steps will be briefly explained next, illustrating the analysis we have done so far. Because of space reasons we will not describe the complete category system in detail. Instead, we focus on the categories that are relevant for our preliminary results.

In the first step of qualitative content analysis, the relevant text samples are chosen out of the complete data sample in accordance

to the research questions and the theoretical background. In our study, we chose samples explicitly mentioning stereotypes (research question 1). We looked for groups ascribed characteristics or attributes and how the students positioned themselves in relation to such groups (research question 2 and 3).

In the next two steps, the relevant text samples are grouped together in accordance to principal topics that can be found in the text samples, and, from them, subtopics are generated. In the forth step, all topics and subtopics are explicated by defining categories and subcategories that describe exactly when a text sample is part of a category or not. Very often typical examples are provided with the category. The categories, together with coding rules and related textual passages, form the category system.

Based on the chosen samples we generated the first main category ***Stereotypes,*** with two subcategories: *socializing aspects* (characteristics that refer to social life: contact to other individuals and attitudes towards them, hobbies, dress and lifestyle) and *gender aspects***.** Students distanced themselves from certain aspects of computing. From these text samples, we generated the next main categories: ***Differentiation*** from (the subcategories): *stereotypes, partial knowledge, CS class in school, CS, computers*; ***Affiliation*** with (the subcategories): *CS class in school, CS, Computers*; and ***Refusal of CS/computers*** due to (the subcategories): *fear, incompetence, dependence, feelings of uselessness.*

Students identified with or distinguished themselves from groups. We denoted this in the main category ***Self-Image***. We found that individuals were describing grouping processes and used them to explain why they considered themselves interested in CS or not. We generated four subcategories: *grouping process, user, nonexpert, expert*.

Once the category system is defined, 10-50% of the data is coded. After the first coding pass, the category system is revised and extended as the last and fifth step. Then the final data coding with the complete data sample is performed. The final coding will be done by more than one person in order to measure intercoder-reliability.

We have revised the categories described in the paragraphs above and currently we are now in the process of final coding using the MAXQDA coding-software [1]. Because we are still in the coding process, these results must be seen as a preliminary outcome.

2.2 Differentiation from Stereotypes

Students (especially non-computing students) frequently use stereotypes in a negative way to differentiate themselves from "nerdy" computer experts:

> *"My prejudices concerning computers, which make things more complicated instead of making them simpler, were confirmed. I felt helpless and always needed to ask my flat-mate's boyfriend for help. He was a real 'freak' and was able to help quickly in most cases, but I always felt uncomfortable, due to the fact that I seemed 'stupid', and guilty, because I didn't keep in touch with him otherwise (well, computer-freaks are usually boring) and I felt I was using him.* [07P1979wU6].

Biographies frequently reproduce negative stereotypes. Many of our biographies use the negative stereotype as a way of explaining their own problems with computing:

> *"I didn't experience any further improvements with the computer, I hadn't had a Commodore 64 like my other friends, but wasn't interested in games only either, so I dissociated myself from the computer and I thought it sucked. In the 11th grade, I had to take CS classes, in which we used DOS. Unlike my friends, I had no clue about it. The computer became a nightmare."* [10P1982wU6]

2.3 Affiliation with Stereotypes

Students often use stereotypes to describe their own identities. In this biography a student who previously enjoyed computers describes how he left computers for a more "punk" image:

> *"In that period I found a computer somehow un-cool and I switched to guitar. This way I got to know many musicians. We practiced hard, started bands, played gigs and were as punk as our stomachs could take it and as much as our parents allowed. I would use a computer only when necessary."* [22ImU8]

Though his reasons for leaving computers are unclear to him, it is clear that being a punk helped him clarify a "cool" identity in his social group.

Similarly, "cool" aspects of computer culture can be attractive for students with interests in computers:

> *"Several years later I saw 'Matrix' in a cinema. Neo, a young hacker, was able find something out due to his computer knowledge exclusively. Something, that was inaccessible for the rest of the human race. This knowledge becomes the power and reason why he starts exploring the new world. This philosophical and, for me, revolutionary idea brought me to the idea of making peace with the computer again.* […] *It didn't take long and I was searching after 'hacker books' in our local library. Suddenly everybody was talking about bank robberies and Trojans, viruses and worms. I dived into this world, which was more interesting then one could imagine."* [07ImU8]

2.4 Ambiguous Stereotypes

Students who seemed to enjoy Computer Science nonetheless took special pains to differentiate themselves from stereotypes.

> *"*[...] *I was beginning to distance myself from people by becoming so closely involved with technology and unique expertise. To be frank I was a little afraid of being sucked into the CS major stereotype of being a pale, scruff poorly dressed student who knew little more than gaming, hacking, and which hardware on the market was the best* […]. *With this realization, I decided to pick up a certificate in information technology through the college of management."* [547580242]

> *"I used it almost every day to play games or to check what it was able to perform, which mades me a computer junkie immediately. However, I was busy not only with computers, but I also had a family and friends with whom I would regularly meet."* [03ImU8]

This emphasis of distinctiveness from the CS stereotype was one of the most frequent commonalities between the US and German biographies. It was these sorts of biographies more than any other that led us to explore stereotypes more closely. Obviously, students in computing think about stereotypes frequently when asked about their relationship to computers. It was a point of

concern for us that excitement about computing seem tied to negative stereotypes even in the minds of computing majors.

3. PSYCHOLOGY OF STEREOTYPES

It should be clear from the patterns we have highlighted in our biographies that students use stereotypes in complex ways when describing their relationship to computing. To help understand these results, the psychology stereotype literature represents a valuable resource. We introduce one theory here, and discuss its implications for our biography results and computing education in general.

Stereotypes are generalizations about groups ([12] pg. 26). When negative generalizations are applied broadly by members of a culture, they can lead to the prejudice and discrimination typically associated with the word "stereotype". However, most modern psychology stereotype research theorizes that the stereotype formation a normal, not pathological, process of cognition. These generalizations also give us useful abstractions that help us understand social situations. Psychologists don't agree on the exact cognitive structure of stereotypes. This paper draws on self-categorization theory, an explanation of stereotypes that we found provided some interesting insights into our biographies.

3.1 Categorization

The basic prediction of self-categorization theory is that individuals will naturally view a social context in terms of two groups: an in-group that is viewed as similar to the self and an out-group that is differentiated from the self. These categorizations change as the social context changes ([9] pg. 87). For example, A CS major in an introductory CS class might feel that he or she is a "CS major" and differentiate him or herself from the "computer enthusiasts" in the class. However, the same CS major might feel a great deal of kinship with the same enthusiasts at a party, regardless of major because the context divides more neatly into "computer /non-computer people".

In real social situations, multiple categorizations are of course possible: individuals are divided by gender, major, dress, hobbies, etc. What makes a particular categorization salient is a combination of a variety of factors [9]:

- *Categorizations explicit in the situation*. The two opposing teams at a sporting event are likely to categorize along team lines. It's important to note that although multiple categorizations are frequently possible, sometimes categorization is so compelling there is no choice.
- *Categorizations that are relevant to personal goals*. If I am trying to find people to help me fix my computer problem, nerdy appearances might become salient
- *Categorizations that have a large amount of meaning*. Categorizations with a large number of associations (like existing stereotypes) will be preferred to categorizations that do not help understand (e.g. hair color).
- *Categorizations that divide the social context*. If everyone falls on one side of categorization, it is not useful for understanding.
- *Categorizations that allow me to establish a positive identity*. If can I see myself in a relatively high status group, I will prefer categorizations that let me do that.

This categorization process naturally lends itself to the use of common stereotypes to make inferences about other group's behavior. It also suggests that stereotypes are naturally used to understand the self. By categorizing oneself, the individual can incorporate a group identity into their view of themselves (at least until the social context changes and the salient categorizations are different).

3.2 Group Identity

A person's categorization of others into groups affects that person's behavior. One of the best known examples of this is called the "minimal group" effect in which individuals categorized into two groups based on arbitrary characteristics (like underestimating or overestimating dots) will, despite the arbitrariness of the categorization, favor their own group members when given the opportunity of the allocate resources between the groups ([12] pg. 238). Individuals also judge a statement made by a member of their own group to be closer to their own opinion, and opinions expressed by members of an out-group to be further from their own ([9] pg. 127-158).

When individuals categorize themselves as members of a particular group, their view of themselves becomes dependent on their perception of the group as a whole. If good characteristics are ascribed to the group, the individuals' self-perception is enhanced by association. Individuals are apt to view positive information about groups they belong to more uncritically to maintain a positive self-identity.

Sometimes group members cannot view their group in a positive way. For example, if a group does poorly on an objective task or if commonly accepted wisdom makes positive comparison impossible (e.g. business students might have a high status when compared to physics majors on the basis of creativity, low status when compared on basis of intelligence). When a group's status is low, it is considered to be under a group-directed "threat" [4]. Group members have a choice: When they feel a low amount of commitment to a group, they are likely to report that they are atypical of the group and potentially affiliate with other groups. Group members with a high amount of commitment emphasize the group's homogeneity, may act in a more stereotypical way, and try to change the group status. Even if status improvement is not possible, high identifiers may continue to affiliate.

When individuals receive information that threatens their sense of membership in a group, it is considered to be a self-directed threat [4]. For example, if someone who considers him- or herself a Computer Scientist has difficulty understanding a class of algorithms (considering algorithmic understanding to be a characteristic of Computer Scientists), external evidence has called into question his or her group membership. Similar to a group-directed threat: group members that have a low amount of commitment are likely to distance themselves (e.g. just decide that they are a Computer Scientist who is bad at algorithms). Group members that feel a high affiliation are likely to take action to restore their perception of acceptance within the group – perhaps by studying that group of algorithms until they are clear.

This process of distancing oneself from a group is known as "individualization". We believe that this is the phenomenon we saw in some of our biographies (section 2.4) – students distancing

themselves as from being classified as "normal" Computer Scientists, because of the implicit low status of the prevalent stereotype about Computer Scientists. Most of our computing majors' biographies expressed excitement about the field of CS itself. But despite this interest in the subject matter of CS, this distancing can be seen as evident individualization and of low commitment to CS.

4. DISCUSSION

What are some possible implications of self-categorization theory for understanding the effects of stereotypes on CS students? The first implication is that stereotypes significantly affect students' self-perceptions as Computer Scientists. This occurs even after the student is officially in the major and ought to be "cured" of stereotypical misconceptions. Because individuals are constantly adjusting their categorizations in view of the social context, seemingly "minor" social issues in the classroom can cause students to categorize themselves in opposition to other Computer Scientists and teachers.

This theory suggests that privileging particular attributes as definitive for CS is likely to have negative effects. When teachers focus on using a particular style of mental process [14] or elevate some students as exemplary Computer Scientists at the expense of others [2], they create a category of enrolled students who are not meeting the standards of Computer Science. If students have a high commitment, threatening their self-image as Computer Scientists can encourage them to work harder. But our biographies suggest that student's commitment to Computer Science may be low. If this is true then challenging student identity is more likely to exclude them than encourage them to work harder.

Self-categorization lends support to the view that CS hurts itself if it enforces one particular vision of the Computer Scientist in the classroom. By promoting different potential CS identities (one potential example could be different specializations in algorithms, systems, languages, etc.), students could be encouraged to categorize between a variety of different choices within CS rather than as CS/not CS. The more choice involved with an identity, and the more unique it is, the more likely it is to have strong affiliation. There are other benefits to strong commitment. When a group categorization becomes central to an individual's identity, the individual is motivated to act in ways that preserve the group's status in order to protect their own identity. When a group is having problems (for example, peers having difficulty in class), individuals who are strongly committed to a group are more likely to work with other group members to preserve their collective identity.

Finally, it can be important to recognize that the same self-categorization processes that affect our students also operate within the wider CS community. If as CS educators, we hope for our educational improvements to be adopted by the CS field at large, we should be aware that we can inadvertently threaten the identities of established members of our field by proposing to change CS in sweeping ways. Stereotype change is in many ways equivalent to a group threat because it casts into question the identities of people well-established under the traditional order. In this way, a potential innovation can lose the support of high affiliators who normally could be counted upon to devote significant time and energy to CS.

Going forward, we intend to finish this study and publish a more complete account of what we elaborated on. We also think that the predictions of self-categorization theory represent an interesting future research direction that should be explored in further detail. Clearly however, the study presented here suggests rather than verifies the claims of self-categorization theory and more stereotype specific research needs to be undertaken before we can understand how stereotypes affect students' self-identities.

5. DISCUSSION QUESTIONS

1. Are the predictions of self-categorization theory useful to us as CS educators?
2. What are the logical next steps, in terms stereotype research for Computer Science?

6. ACKNOWLEDGEMENTS

This research is supported in part by a grant from the National Science Foundation BPC Program #0634629.

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