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Self-to-prototype matching as a strategy for making academic choices. Why high school students do not like math and science

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Abstract

The percentage of school students specializing in math and science is particularly low. The current research suggests that this is due to prototypes about math and science being highly dissimilar from self-prototypes students have or want to have of themselves. Going beyond previous studies on self-to-prototype matching, we assumed that students compare their self-views to both a prototypical student liking a certain subject (*favourite-subject-prototype*) and a prototypical student disapproving of it (*least liked subject-prototype*). Results show that for humanities (German and English language), favourite-subject-prototypes were judged more positively than least-liked-subject-prototypes, whereas for science (math and physics), least-liked-subject-prototypes were perceived as more positive than favourite-subject-prototypes. As expected, only if a student's self-prototype was quite clear (high self-clarity) was it used as a standard against which school-subject prototypes were compared with respect to their degree of overlap. Our results showed that the better the match between self and favourite-subject-prototype, the stronger were the subject preferences.

Keywords: Self-to-prototype matching; Academic choices; Prototypes; Self and identity

1. Introduction

The percentage of school students specializing in natural sciences is extremely low. To give an example from the United Kingdom, in a sample of 7649 students aged 16 (Schoon, 2001) only 5.5% of the boys and 1.5% of the girls aspired to enter

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a job in the realm of natural sciences (among others, chemists, biologists, biochemists, and physicists). For Germany, Berlin's statistic (Landesschulamt Berlin, 1999) shows that biology, English, and German are at the head of a ranking list of the most frequently chosen majors in high school, whereas physics is classed behind math, geography, art, and politics on rank eight. Shown in percentages, only about 10 percent of all students choose physics and less than 10 percent choose chemistry as their major subject (http://www.think-ing.de/html/news/news200002010194.htm; Roeder & Gruehn, 1997). Furthermore, in Germany the percentage of students choosing natural sciences as a major subject was cut to half within the last 20 years (Zwick & Renn, 2000; a similar development in the UK is documented in The Report of Sir Gareth Roberts' Review, 2002, http://www.hm-treasury.gov.uk/documents/enterprise_and_productivity/research_and_enterprise/ent_res_roberts.cfm). Other studies have shown that when asked to rank school subjects according to personal preference, typically, languages as compulsory humanities subjects are at the head of the list, while the sciences are at the far end of it (Süllwold, 1989; Zwick & Renn, 2000).

Over the last decades, researchers from many different disciplines (psychology, education science, didactics for physics, chemistry, and maths) have been trying to identify the factors that contribute to students' reluctance to enter the math and science field and thus to reduce barriers in approaching corresponding occupations. One of the driving forces behind this kind of research is the recognition that literacy in math and science affects economic productivity. World-class competence in these subject domains is essential to compete successfully in today's global marketplace. Accordingly, successful careers are found more and more often in the realms of technology and natural sciences.

2. Theoretical framework

2.1. Acquisition of self-knowledge in the school context

Psychological research on the advancement of students' participation in the sciences has typically focused on achievement related variables—such as aptitudes, prior knowledge, previous achievement-related experiences, self-concept of one's abilities, expectation of success, subjective values, attitudes, norms, attribution of performance outcomes, and achievement-motivation. In contrast, in the present paper we want to elaborate on the reasons of students' dislike for sciences from a *genuinely social psychology perspective*. We will argue that notwithstanding the important contribution of achievement related variables, school students' avoidance of the sciences is due to (a) the specific image this subject domain has (in comparison to other domains) and (b) the image students of the relevant age group have of themselves or want to have of themselves. We assume that the general image of science subjects and students' self-image are highly incompatible. Consequently, school students do not like science subjects.

The acquisition of a self-image, i.e. the knowledge about one's self, shapes the personality and behaviour of an individual throughout the life span (Hannover, 1997). It has, however, a particularly strong impact during the first two decades of life. As individuals move through childhood and adolescence, different self-related goals become salient in response to changing conditions, such as biological changes (e.g. puberty), cognitive (e.g. achievement of different stages of cognitive development) and social changes (e.g. entering high-school). As a result, the child or adolescent constantly acquires new self-knowledge, i.e. he or she incessantly engages in self-definition, with the process of self-definition being active and self-initiated (Ruble, 1994).

In the school context, in order to obtain new self-knowledge, students may choose to enter social situations in which they can express behaviours that they believe to be relevant to their actual or desired self-definition. In order to constantly adapt their self-image to a changing environment, they may also search for situations in which they can elicit self-verifying feedback with respect to the characteristics they ascribe or want to ascribe to themselves (Hannover, 1998). Consider the introduction of the new subject physics in the seventh grade of high school as an example. As has been described in more detail in the work by Ruble (1994), in such a new psychological situation, the student concentrates on the defining features and procedures of the new topic, thus actively gathering information in order to draw inferences about the topic's applicability and relevance to the self. In other words, the student may focus on the relevance of the new subject physics to his or her self-definition and his or her liking for physics may vary according to the self-relevance attached to the new subject.

2.2. *The self-to-prototype matching approach*

We want to propose that in order to evaluate the self-relevance of a new psychological situation, people engage in *self-to-prototype matching*. The prototype concept suggests that object perception is organized around a typical, average or modal "best example" (Rosch, 1973). Individuals have prototypes in memory about themselves (*self-prototype*, Kihlstrom & Cantor, 1984), about other persons (*person-prototypes*, Cantor & Mischel, 1979) and about situations in terms of prototypical persons to be found in them (*person-in-situation prototypes*, Cantor, Mischel, & Schwartz, 1982). Person-prototypes can contain stereotypical beliefs about the group the person is a member of: While a stereotype is a cognitive representation or impression of a social *group* that people form by associating particular characteristics with that group (Eagly & Mladinic, 1989; Hamilton, 1981), a prototype describes just *one person*, who is considered as a particularly typical representative of the group in question (for example the "typical teacher").

Niedenthal, Cantor, and Kihlstrom (1985) and Setterlund and Niedenthal (1993) have extended the *person-in-situation prototype approach* to the *self-to-prototype matching approach*. They suggest that to make choices among alternative situation options, individuals imagine the prototypical persons who would be found in each of the available options. In a second step, the individual compares the defining characteristics of these prototypes with those of his or her actual or desired self and chooses the alternative which provides the best match between the self-prototype and the prototypical person. For example, consider a person who wants to buy a new piece of clothing on the occasion of a dinner party invitation. While he or she is flicking through a fashion magazine and looking at various outfits, he or she may imagine the prototypical buyer for each of the piece of clothing. The individual's self-definition serves as a reference point against which the features of these prototypical persons can be compared. The person is therefore expected to buy the piece of clothing which most closely reflects the image he or she has of himself or herself, i.e. for which he or she has found the strongest similarity or overlap between the prototypical person wearing that outfit and his or her own self-image.

2.3. Self-to-prototype matching in the school context

Applied to the school context, when being asked how much one likes a certain subject, when choosing a major subject in high school, when deciding whether or not to pursue a certain school subject, or when deciding for which courses to enrol, we expect students to engage in self-to-prototype matching. When making such choices freely, we predict students to imagine prototypical students for each of the situation options, for instance the prototypical student whose favourite subject is math, physics, or English. The student may than calculate the overlap between his or her self-image and the prototypical image. The stronger the overlap between the self-image and the prototypical image of a student with a particular favourite subject, the more likely the individual will approve of the respective subject.

However, we have to qualify this assumption in two respects. As shown by Setterlund and Niedenthal (1993), individuals differ in the extent to which they engage in prototype-matching. More precisely, a prerequisite for using the strategy is that the person has a clearly defined image of himself or herself, i.e. high self-clarity: Only if I know who I am can I use my self-image as a reference point against which features of prototypes can be compared according to their degree of overlap or similarity. Campbell (1990) found that people differ in the extent to which the contents of their selves are defined in a clear and confident, temporally stable, and internally consistent manner. Applied to our problem, only students who have a sufficiently clear image of who they are, are expected to use self-to-prototype matching as a basis for their academic choices in school.

The second qualification refers to the fact that so far, we have only considered free and positive choices, i.e. situations in which the individual can actively choose between several options but can also refrain from entering any of the available situations. Niedenthal et al. (1985) and Setterlund and Niedenthal (1993) had their research participants choose among a set of positive options, e.g. preferring one car over some others, visiting one type of restaurant rather than another or renting one out of several apartments. At school, however, free and positive choices are limited to optional courses or additional courses and to the choice of subject majors in high school. In most situations students do not have a choice: They have to do math, they have to do physics, and languages at least throughout their compulsory school years.

Therefore, going beyond the assumptions of Niedenthal and coworkers (Niedenthal et al., 1985; Niedenthal & Mordkoff, 1991; Setterlund & Niedenthal, 1993), we want to suggest that in a no-choice situation, when forced to enter a certain situation, for instance to enrol in mathematics, students may imagine both a prototypical student whose favourite subject is math, and a prototypical student whose least liked subject is math. In the following, we will refer to the prototype of the student who chooses a certain school subject as his or her first preference as *favourite-subject-prototype* and to the prototype of the student choosing that subject as the least preferred one as *least-liked-subject-prototype*. The student may than calculate the overlap between his or her self and both prototypes. To the extent that the overlap between self-image and favourite-subject-prototype increases and the overlap between self-image and least-liked-subject-prototype decreases, will the individual approach the respective subject area.

3. Study overview and expected results

Our assumption that students engage in self-to-prototype-matching to direct their academic interests presupposes that prototypes about school students whose favourite subject or whose least liked subject is within the realm of humanities or science, respectively, do in fact differ from one another. Therefore, in a first step we will try to identify and describe these different prototypes. We will then go on by testing our assumption that school students make academic choices or preferences dependent on the degree of overlap between prototypes about different school subjects and the image they have of themselves.

In adapting and extending the hypotheses derived from self-to-prototype matching theory (Niedenthal et al., 1985; Setterlund & Niedenthal, 1993) to school subject preferences, we predict the following:

- The prototypic student who prefers science as a favourite subject is conceived of differently than the prototypic student who disapproves of science and differently than the prototypic student who prefers humanities as a favourite subject.
- Students' prototype of a student favouring science is less similar to their self-image than their prototype of a student disapproving of science and their prototype of a student favouring humanities.
- When freely making choices, people strive to maximize the similarity between what they believe about themselves and the prototypical person who would choose the respective option. However, since at school enrolment in compulsory courses cannot be avoided (by voting out), students compare their self-image with both a favourite and a least-liked-subject-prototype. Only to the extent that the overlap between self and favourite-subject-prototype increases and the overlap between self and least-liked-subject-prototype decreases, will the student approach the respective school subject.

- Since the attributes of the self provide the standard against which features of the prototypes are compared, students with low self-clarity do not engage in self-to-prototype matching.

To test these assumptions, we had students (a) describe prototypes of students with a liking or disliking of different school subjects (physics, math, English, German) and (b) describe themselves. For both the description of the prototypes and of the self, the same questionnaire was used, containing 65 trait adjectives. Also, students' self-clarity and liking for different school subjects were measured.

4. Method

4.1. Participants

Research participants were 105 students of the 9th and 8th grade from a high school in Northrhine-Westfalia, Germany (62 boys, 43 girls). The mean age was 14.8 years ($SD = 0.68$). Students volunteered to participate in the study.

4.2. Instruments

The participants completed a questionnaire during a school lesson. First, prototypes were measured. Half of the participants ($n = 53$) were asked to describe four favourite-subject-prototypes: the typical boy/girl whose favourite subject is mathematics/German/physics/English. The other half ($n = 52$) were asked to describe four least-liked-subject-prototypes: the typical boy/girl whose least liked subject is mathematics/German/physics/English. To avoid sequency effects, the order in which the prototypes were to be described was determined by a Latin Square Design. Female participants were asked to describe the typical girl, male participants were asked to describe the typical boy. For each prototype, a total of 65 trait adjectives had to be rated according to how well they described the prototype.[1] 7-point scales were used with 1 standing for the attribute not being typical at all and 7 for the attribute being very typical. Then, the students were asked to rank order 14 school subjects. Rank 1 meant that they preferred the subject most and rank 14 that this was their least liked subject. Combined ranks were not allowed.

Next, the Self-Clarity-Questionnaire by Campbell et al. (1996) followed. It consists of 12 items that measure the clarity of one's self, e.g. "My beliefs about myself seem to change very frequently" and "On one day I might have one opinion of myself and on another day I might have a different opinion"; a 5-point scale is used, with 1 standing for *strongly agree* and 5 for *strongly disagree*.

[1] The trait adjectives used for the description of the prototypes were derived from four pilot studies, in which we used qualitative, open measurements.

On the following page the students had to describe themselves, using the same 65 trait adjectives and the same scale used for the description of the prototypes. Finally, age, class and sex were asked.

5. Results

5.1. Comparison of favourite-subject prototypes and least-liked-subject-prototypes

In order to describe variations between prototypes according to school subject and according to the prototypic student preferring or disliking the subject., we had to aggregate the trait adjective ratings. To achieve this, we used students' self-descriptions. In particular, we conducted a factor-analysis on students' self-descriptions on the 65 trait adjectives. A PCA resulted in 18 factors with $\lambda > 1$. According to the scree test, five factors were extracted, the fifth having an eigenvalue of $\lambda = 2.72$. The five factors accounted for 45.2% of the variance. The first factor included 16 traits referring to *physical and social attractiveness* (e.g. "attractive", "popular", "athletic", "erotic", and "respected"). The second factor comprised 18 traits that stand for *social competence and integration* (e.g. "talkative", "open-minded", "inhibited (–)", "lonely (–)", and "isolated (–)"). The third factor consisted of 10 adjectives that refer to *intelligence and motivation* (e.g. "educated", "intelligent", "diligent", "ambitious", and "brilliant"). The fourth factor contained 9 traits about *arrogance and self-centeredness* (e.g. "pompous", arrogant", "stubborn", "be a know-it-all", and "self-centered"). The fifth factor consisted of 10 adjectives referring to *creativity and emotions* (e.g. "creative", "inventive", "imaginative", "romantic", and "empathetic"). After excluding two traits that did not seem to fit to the factors they loaded on ("opinionated" and "slim") we calculated means across the variables of each factor. All scales had satisfying internal consistency: For physical and social attractiveness Cronbach' s alpha was 0.91, for social competence and integration 0.88, for intelligence and motivation 0.78, for arrogance and self-centeredness 0.81 and for creativity and emotions 0.77.

For each of the eight different prototypes, we now calculated means across the variables of each of the five factors which we had extracted from students' self-descriptions. In so doing, a common aggregation strategy could be applied to all prototypes irrespective of the school subjects to which they corresponded. As expected, the pattern of descriptions on the 65 adjectives was quite similar within the two school subjects representing the same domain (math and physics/German and English) but different between domains (humanities versus science). We therefore collapsed the descriptions across physics and math on the one hand and across German and English on the other. We were now in a position to test our hypothesis that the prototypic student who prefers science as their favourite subject is conceived differently than the prototypic student who disapproves of science and differently than the prototypic student who prefers humanities as their favourite subject.

To test this assumption, for each of the five factor dimensions we conducted 2 (gender) $\times$ 2 (favourite/least-liked-subject-prototype) $\times$ 2 (humanities/ science) analyses of variance, with gender and favourite vs. least-liked-subject-prototypes as between subjects factor and humanities vs. science as within-subjects repeated measurement factor. As explained above, sex of target person corresponded to sex of rater.

Our hypothesis would be met by statistical interactions between the favourite vs. least-liked-subject-prototype factor and the repeated measurement factor. For the sake of clarity, we will not report unexpected main effects which occured as concomitant phenomena of these statistical interactions, as they do not provide any additional information concerning our hypotheses. The means pattern is displayed in Fig. 1.

5.1.1. Manova on physical and social attractiveness

As expected, the Manova on *physical and social attractiveness* revealed a statistical interaction between the favourite vs. least-liked-subject-prototype factor and the repeated measurement factor, $F(1, 101) = 28.05$, $p < 0.001$, indicating that students who favour science were judged as more unpopular and more unattractive ($M = 3.46$, $SD = 0.85$) than any other student group (students disapproving of science: $M = 4.59$, $SD = 1.12$; students favouring humanities: $M = 4.45$, $SD = 0.84$, students disapproving of humanities: $M = 4.37$, $SD = 0.89$). No main effect or interaction including gender occurred.

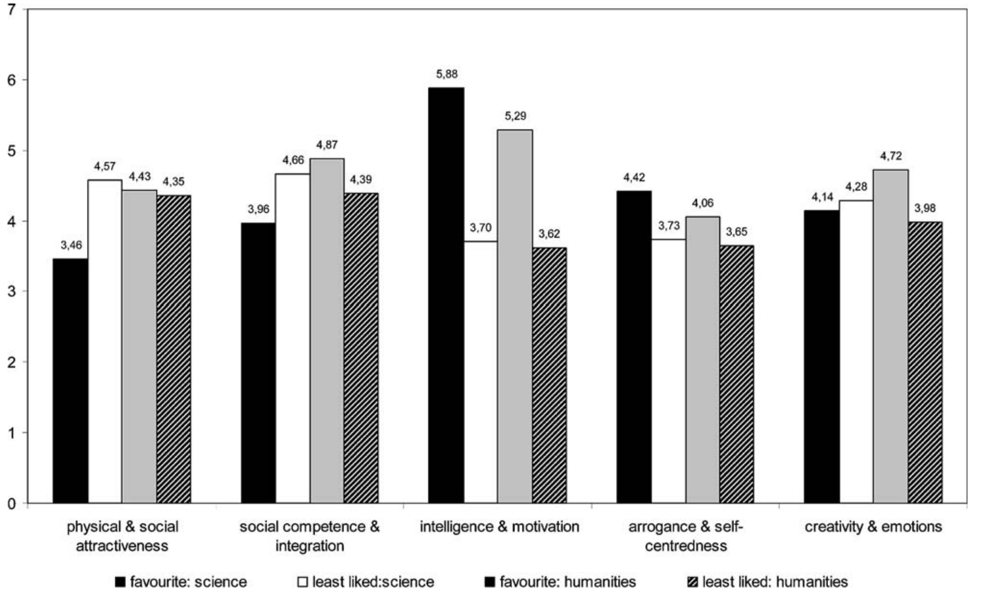

Fig. 1. Mean ratings on five factors for prototypes about science and humanities.

5.1.2. Manova on social competence and integration

Again as expected, we found an interaction of the favourite vs. least-liked-subject-prototype factor with the repeated measurement factor, $F(1, 101) = 39.40$, $p < 0.001$: While students who favour science were thought to be less socially competent and less integrated ($M = 3.96$; $SD = 0.77$) than students who do not like these subjects ($M = 4.66$; $SD = 0.80$), the opposite hold true for humanities: Who dislikes humanities, was considered less socially competent and less integrated ($M = 4.40$; $SD = 0.72$) than someone who likes them best ($M = 4.89$; $SD = 0.68$). No main effect or interaction including gender occurred.

5.1.3. Manova on intelligence and motivation

We again obtained an interaction of the favourite vs. least-liked-subject-prototype factor with the repeated measurement factor, $F(1, 101) = 7.08$, $p < 0.01$. The means pattern revealed that the prototypical student whose favourite subject is science was considered to be more intelligent and motivated ($M = 5.88$; $SD = 0.84$) than the prototypical student who favours humanities ($M = 5.30$; $SD = 0.87$), whereas no difference appeared for the least-liked-subject-prototypes (least-liked-subject humanities: $M = 3.64$; $SD = 0.85$ vs. least-liked-subject science: $M = 3.71$; $SD = 1.07$). No main effect or interaction including gender occurred.

5.1.4. Manova on arrogance and self-centeredness

No significant interaction was found. A main effect for favourite vs. least-liked-subject-prototype factor, $F(1, 101) = 16.58$, $p < 0.001$, reveals that in general, a student who strongly dislikes a school subject was considered less arrogant and less self-centered ($M = 3.68$; $SD = 0.76$) than a student who has a favourite subject ($M = 4.23$; $SD = 0.58$). A main effect of the repeated measurement factor, $F(1, 101) = 5.18$, $p < 0.05$, exhibits that greater arrogance and more self-centeredness were ascribed to students that were to be judged in relation to science ($M = 4.07$; $SD = 0.91$) than to students judged with regard to humanities ($M = 3.84$; $SD = 0.82$).

5.1.5. Manova on creativity and emotions

As expected, a statistical interaction between the favourite vs. least-liked-subject-prototype factor and the repeated measurement factor emerged, $F(1, 101) = 32.49$, $p < 0.001$: Students whose favourite subject is from the humanities were thought to be much more creative and emotional ($M = 4.71$; $SD = 0.65$) than students who dislike these subjects ($M = 4.00$; $SD = 0.75$). In comparison, liking or disliking science had a comparatively smaller effect on the ascription of creativity (favourite subject science: $M = 4.14$; $SD = 0.71$, least liked subject science: $M = 4.28$; $SD = 0.85$). A three-way-interaction between favourite vs. least-liked-subject-prototype factor, repeated measurement factor and sex of students, $F(1, 101) = 5.92$, $p < 0.05$, is due to the fact that for girls, the ascription of creativity was much more dependent on their liking ($M = 4.93$; $SD = 0.65$) or disliking humanities ($M = 3.81$; $SD = 0.88$), than was the case for boys (boys liking humanities: $M = 4.55$; $SD = 0.62$; boys disliking humanities: $M = 4.12$; $SD = 0.63$).

To summarize, the prototypes were conceived of differently on several dimensions: The prototypic student approving of science was described as being less physically and socially attractive, less socially competent/integrated, less creative/emotional, but as more intelligent/motivated compared to the prototypic student preferring humanities and to students disapproving of science subjects.

5.2. *Self-to-prototype matching*

In order to test our assumption that the degree of overlap between prototype and students' self-views varies according to the subject being from the humanities or from the sciences, we had to compare the prototypes with students' self-descriptions. To achieve this, we computed individual self-to-prototype matching scores separately for the four prototypes. For each of the 65 trait adjectives, the absolute difference between an individual's self-description and this individual's description of the respective prototype was calculated, summed up and divided by 65. The resulting score can vary between 0 (self and prototype are described completely alike) and 6 and is the larger, the more an individual's self-description deviated from this person's description of the respective prototype. For the students who had rated the favourite-subject-prototypes, this procedure yielded four scores, describing the similarity between each participant's self and this student's perception of the prototypical student whose favourite subject is German, English, math, or physics. For the other half of the students who had rated the least-liked-subject-prototype, the resulting four scores describe the similarity between each participant's self and this student's perception of the prototypical student whose least liked subject is German, English, math, or physics.

We again aggregated the scores across math and physics into science on the one hand and across English and German into humanities on the other. We performed a 2 (gender) $\times$ 2 (favourite/least-liked-subject-prototype) $\times$ 2 (humanities/science) analysis of variance, with gender and favourite vs. least-liked-subject-prototypes as between subjects factors and the ratings of humanities/science as the within-subjects repeated measurement factor. The means pattern is shown in Table 1. The analysis revealed an interaction between the favourite vs. least-liked-subject-

Table 1
Self to prototype matching scores (distance scores) for science[a] and humanities[b]

		Boys		Girls	
		M	*SD*	*M*	*SD*
Similarity between self and favourite-subject-prototype	Science[a]	2.00	0.49	1.91	0.67
	Humanities[b]	1.64	0.53	1.47	0.48
Similarity between self and least-liked-subject-prototype	Science[a]	1.77	0.59	1.78	0.64
	Humanities[b]	1.65	0.64	1.86	0.55

[a] Math and physics.
[b] German and English.

prototype factor and the repeated measurement factor, $F(1, 100) = 15.58$; $p < 0.001$: The participants felt less similar to a student who has science as his or her favourite subject ($M = 1.96$; $SD = 0.57$) than to a student whose least liked subject is science ($M = 1.72$; $SD = 0.61$), whereas they felt more similar to a student who has humanities as his or her favourite subject ($M = 1.57$; $SD = 0.52$) than to a student whose least liked subject is from the humanities ($M = 1.81$; $SD = 0.60$). As a concomitant phenomenon of this interaction, a main effect for the repeated measurement factor occurred, $F(1, 100) = 5.42$, $p < 0.05$, indicating that the participants felt a greater distance to students who were described in relation to science ($M = 1.84$; $SD = 0.60$) than to students related to humanities ($M = 1.67$; $SD = 0.57$). Notably, no interaction with gender was observed.

5.3. Prototype matching and self-clarity

From the individual lists of liking for different schools we extracted the ranks each participant had given to the four school subjects for which we had also obtained the prototypes: physics, math, German, and English. We now computed rank correlations between the person's self-to-prototype matching-score and his or her rank of liking for the respective school subject. The resulting correlation is the larger, the more strongly participants had engaged in self-to-prototype matching as a cognitive strategy in order to decide on which rank of liking to place a particular school subject. We have assumed that students with low self-clarity do not engage in self-to-prototype matching, since the attributes of the self provide the standard against which features of the prototypes are compared. Accordingly, for participants high in self-clarity who had filled out the favourite-subject-prototype version of the questionnaire, positive correlations were expected, whereas for participants high in self-clarity who had filled out the least-liked-subject-prototype version, negative correlations were expected. For students low in self-clarity, no covariation between matching-scores and school-subject preferences was expected.

For each participant, a mean score was computed on the items of the self-clarity scale. The scale's Cronbachs alpha was 0.76. The mean scores ranged from 1.67 to 4.33. Via median split (median: 2.92), we distinguished between participants low ($n = 54$) and high ($n = 49$) in self-clarity.

Table 2 depicts that, as expected, only for students with sufficient self-clarity liking of school subjects and favourite-subject-prototype-matching scores were correlated: The more similar a person's self-image was to his or her prototype of a student preferring a school subject as favourite one, the stronger the person's liking for that subject. There was an exception to that rule, however: liking for physics did not correlate with the self-to-favourite-subject-prototype matching score ($r = 0.12$). This result is probably due to distribution characteristics concerning the ranking of physics: Physics was placed on the last ranks ($M = 8.96$; $SD = 3.50$), skewness of the distribution amounted to -0.46. The Kolmogorov–Smirnov-Test indicated that the distribution of ranks for physics deviated from a normal distribution ($Z = 1.33$, $p = 0.06$).

Table 2
Rank correlations between favourite-subject-protoype and liking and between least-liked-subject-prototype and liking for students high or low in self-clarity

Rank liking		Math	Physics	English	German
High self-clarity	Self-to-favourite subject-prototype-matching score	0.52^{**}	0.12	0.63^{***}	0.38^{*}
	Self-to-least-liked-subject-prototype-matching score	-0.55^{**}	-0.34	0.05	-0.23
Low self-clarity	Self-to-favourite-subject-prototype-matching score	0.21	0.03	-0.25	-0.03
	Self-to-least-liked subject-prototype-matching score	0.14	-0.25	-0.05	-0.21

Note: $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Table 2 also reveals that our expectation referring to the least-liked-subject-prototypes was not met: Only for mathematics was the extent to which a student conceived of himself or herself to be similar to the prototypical student disapproving of mathematics correlated with his or her liking for math. The correlation coefficient for physics turned out in the expected direction but failed to reach statistical significance ($r = 0.34$, $p = 0$ .14).

As expected, for students low in self-clarity no significant correlation coefficients were observed, i.e. there was no indication that they engaged in self-to-prototype matching in order to decide where to place a school subject on the rank list of liking.

6. Discussion

We have assumed that high school students have particular prototypes about the sciences that may contribute to their not liking math, physics, and chemistry. As expected, results revealed significantly different prototypes according to the school subject and according to the prototype referring to a person liking or disliking a particular school subject. Some interesting regularities appeared. Whereas for physics and math, the prototypic student disapproving of them was described as more physically and socially attractive, as less isolated and better integrated, as more creative and more emotional than the student in favour of them, the opposite was true for German and English language. To summarize, for the sciences, the prototypical student who does not like them was perceived as more positive than the student who prefers them as favourite subjects, with the only exception of more intelligence being attributed to the students approving of the sciences. In contrast, for humanities, the prototypical student who prefers them as favourite subjects was rated more positively than the student who does not like them, with the only exception of more arrogance being ascribed to the students approving of humanities.

Our students' perception of the prototypical peer favouring the sciences was less similar to their self-image than their prototype of the peer disliking sciences and their prototype of the peer favouring humanities. According to self-to-prototype matching theory, this may explain why the large majority of high school students prefers humanities over sciences. It could however be argued that simply the fact that the prototype of math and physics was so negative is sufficient to explain the students' dislike, with no need of self-to-prototype matching necessarily being involved.

This alternative explanation can however be ruled out by the differential results we have obtained for students high and low in self-clarity. As expected, only in students who had a clear and confidently defined image of who they are were school subjects preferences correlated with the degree of overlap between self and favourite-subject-prototypes. In particular, the smaller the discrepancy between an individual's perception of the prototype and his or her self-image, the stronger was his or her liking of the respective subject. The fact that liking of physics did not correlate with students' self-to-prototype matching scores can be explained by the distribution of ranks of liking for physics being highly skewed, such that the presupposition for computing a covariation with the discrepancy scores was not met. As we had expected, students who did not have a clear self-image against which features of the prototypes could possibly be compared did not make use of the matching strategy when deciding where to place a school subject in the list of liking. For these students, no covariation between their liking of a subject and the similarity between their self and the respective prototype was observed.

The differential pattern we have obtained for students high and low in self-clarity is indirect support for our assumption that students do in fact use the self-to-prototype matching strategy in order to direct their interests and choice behaviour in school. If the negativity of the prototype of students favouring sciences were in itself responsible for students' dislike, we would have expected the degree of overlap between self and prototype to covary with subject preferences in both students high and low in self-clarity to the same extent.

With our study we have tried to enhance the applicability of the self-to-prototype matching approach to situations in which the individual does not have the choice to not enter any of the situation options, which is a central feature of the school environment. However, our expectation that in such a no-choice situation, individuals would compare features of their self-concept not only with prototypical persons choosing any of the available options, but also with prototypical persons avoiding the available options was not supported by our data. In particular, we did gain evidence that, exclusively for mathematics, our students compared their self-view not only with the prototypical student approving of math but also with the prototypical student disapproving of math. For physics and German, school subject preferences correlated negatively but not significantly with the degree of overlap between self and the prototypical student disliking these subjects, and for English, students' liking was completely independent of the extent to which they conceived themselves to be similar to the prototypical student disapproving of English.

A possible explanation is that the extent to which prototypes of people in favour of a certain choice option or prototypes of people refraining from that option are respectively used depending on their relative strength, vividness, or accessibility. In our study, the strongest correlations between self-to-prototype matching scores and personal liking were obtained for mathematics. Here, the degree of overlap between a student's self-view and the student's perception of both the prototypical student in favour of math and the prototypical student disapproving of math predicted personal liking for math. Intuitively, it makes sense to assume that for mathematics, there is a strong typical "best example" (Rosch, 1973) for both a student preferring math as favourite subject and a student disapproving of math as least liked subject. Presumably, for other school subjects prototypes about students in favour of them and prototypes about students disapproving of them differ in their accessibility. For instance, it makes sense to assume that the prototypes about students disapproving of German or English are less strong or less vivid than prototypes about students in favour of German or English and therefore less likely accessed when engaging in self-to-prototype matching.

Both boys and girls felt more similar to a peer who favours humanities than to a peer preferring science to the same extent. Because girls' distance-score between self and science-prototype was not larger than boys', our self-to-prototype matching approach in the present study cannot explain the particularly weak interest of girls in science (e.g. Hannover & Kessels, 2002a; Hoffmann, Häußler, & Lehrke, 1998; Roeder & Gruehn, 1997). In order to obtain equally valid self-to-prototype matching scores for both girls and boys, we had exclusively selected trait terms that had no gender connotation. Thus, the self-descriptions of boys and girls varied only slightly between the genders: Girls perceived themselves as more socially competent and more creative/emotional than boys did; on the other dimensions, girls' and boys' self-views converged. This may explain why our students' descriptions of the prototypes did not vary between the genders. Accordingly, no gender-differences were to be expected in the degree of overlap between self and prototypes either. Therefore, in order to shed light on the causes of the particularly weak interest of girls in the sciences, it remains an interesting task for future studies to extend the self-to-prototype matching-approach to gender-aspects of school subject prototypes. Since other studies have shown students' perceptions of science students (Lee, 1998) or scientists (Görzig & Ayman, 2003; Marro & Vouillot, 1991) to be gender-typed, the dissimilarity between girls and the typical student favouring science should increase substantially if it was measured on dimensions as masculinity and femininity. Girls' matching on specifically these gender-typed dimensions might be one explanation why they turn away from science during adolescence.

The present study aimed at identifying the psychological mechanism that directs the development of interests at school. Our results provide one explanation for the low aspirations of German students to enter a career in the realm of natural science today; a development that is leading to a serious lack of highly skilled professionals in this field. The importance of the self-to-prototype matching strategy for people's *vocational choices* has been emphasized by previous findings. Several studies found that in order to choose an occupation, individuals match self-perceived interests and abilities to certain characteristics of the job alternatives they consider, among others personality and physical features of the individuals working in these positions (e.g., Holland, 1985; Kessels & Hannover, 2002; Moss &

Frieze, 1993; Rounds, Dawis, & Lofquist, 1987). Our study adds to these findings by the transfer to a new age group (secondary school students) and a content area (liking/ disliking school subjects) that precedes and influences vocational choices (Schnabel & Gruehn, 2000).

Taken together, results of our study suggest that the discrepancy between the image students have of a peer preferring science and the image they have of themselves seems to be a serious obstacle when trying to encourage students to enrol in science courses at high school or university level. How can we overcome this?

First, by understanding the development of the negative perception students have of the prototypical student approving of science. Prototypes are acquired by extracting an average case from frequent observations. Accordingly, it makes sense to assume that students abstract prototypes about school subjects from repeated experiences, e.g. from frequently observed *scripts* of instruction and interaction associated with different school subjects. Indirect support for this assumption stems from the cross-cultural TIMSS videotape classroom studies (e.g. Klieme, Knoll, & Schümer, 1998). Here, it was found that scripts that were identified as guiding principles of mathematics lessons differed between countries. While mathematics lessons in both poor achieving Germany and the USA were found to consist mostly of a strongly narrow-focused classwork, lessons in top performing Japan included group work, students' presentations and discussions about different ways of solving a problem. Possibly, the script of instruction that guides math and science lessons in German schools is responsible for the development of the prototype of a typical student favouring these subjects that we have found in our study: the prototype of a student who is socially incompetent, isolated and not creative. If this is the case, changing the script of instruction in math and science (e.g. by emphasizing discussion and interaction between students) may change the negative perception students have of the prototypical student approving of these subjects.

It is also possible that school subject related prototypes are explicitly taught, e.g. by older peers or the media. This assumption is supported by the fact that students hold negative attitudes towards science even before their first school lesson in physics or chemistry (e.g. Hoffmann, Häußler, & Lehrke, 1998).

Second, in order to reduce barriers in approaching the science field, we shall try to narrow the gap between students' self image and the stereotypical beliefs they hold about peers preferring science. Various measures have to be taken in order to change the negative prototype or stereotype of science. Stereotypical beliefs (which constitute prototypes) are changeable via contact with members of the stereotyped group when several conditions are met (for a review, see Smith & Mackie, 2000): Effective contact has to provide stereotype-inconsistent information that is repeated (so that it cannot be explained away), that involves many group members (so that subtyping is prevented) and that comes from typical group members (so that contrast effects will not occur).

In fact, in an intervention study we were able to show that stereotypes/prototypes about science can be changed by providing stereotype inconsistent information (Hannover & Kessels, 2002b): After several days of personal interaction with a university scientist (during an optional science course aimed at encouraging pupils to pursue a scientific career), our participants reported a smaller discrepancy between their image of the typical engineer and themselves than before this contact had taken place.

Another more indirect and long term strategy to change the stereotype of science is preventing its activation or application in the school context. To elucidate the conditions depending on which the stereotype is or is not applied during science lessons remains a task for future studies.

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