How choosing science depends on students' individual fit to 'science culture'

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Abstract

In this paper we propose that the unpopularity of science in many industrialized countries is largely due to the gap between the subculture of science, on the one hand, and students' self-image, on the other hand. We conducted a study based on the self-to-prototype matching theory (Burke & Reitzes, 1981), testing whether the perceived mismatch between the typical representative of the science culture (the science *prototype*) and students' self-image is linked to not choosing science as a major. Fifty-four Dutch 9^{th}-grade students currently choosing their subject majors (so-called *profiles*) completed a Dutch version of a questionnaire previously designed by Hannover and Kessels (2004), which measures students' perceptions of typical peers favouring different school subjects (prototypes for physics, biology, economics, languages) and students' self-image. Students chose a profile to the extent that they conceived of themselves as similar to the typical peer who likes the key subject of that profile. Fifty percent of variance was explained when using an aggregated science vs. humanities distance score and predicting whether a student had chosen a science- or a humanities-related profile. A comparison of Dutch students' description of the physics prototype with the German data from Hannover and Kessels (2004) revealed similar prototypes in both countries. The traits ascribed to the physics prototype were in line with science-related values and the culture of science as described by Merton (1973) and Traweek (1992), for example. The relevance of the perceived fit of the culture of science to students' selves for academic choices is discussed.

Introduction

Like many other industrialized countries (Roth, 2003), the Netherlands faces a serious shortage of students who choose a technical or scientific career after upper secondary education (Axis, 2003). Science is unpopular with students, especially with female students (van Langen, 2005). The rate of young people entering the field of science and engineering (S&E) is even lower in the Netherlands than in the surrounding countries (OECD, 2005).

It is widely believed that more science and engineering students are needed given the challenges facing the Dutch economy (Van Bragt, Bakx, Van der Sanden & Croon, in press). Although the implementation of various initiatives by the government has resulted in a gradual increase in students who go on to study science at the university level, the numbers are still insufficient (e.g. Axis, 2003; HBO-raad, 2006). Similar problems occur in Germany.

As Hannover and Kessels (2004) have argued, explanations why students choose or refuse to choose science usually focus on variables linked to achievement or motivation (e.g. previous achievement, achievement-motivation, expectation of success, subjective values, attitudes, norms, attribution of performance outcomes). But in addition to these factors, specific qualities of science and/or school science may contribute to its unpopularity.

The present study seeks to demonstrate how choosing science as a major relates to students' perception of the typical characteristics of prototypical peers who prefer science or other subjects. In a nutshell, we propose that the lack of students in the field of S&E is related to the fact that students do not want to associate with 'science culture'.

Science culture and cultural border crossing

Several authors describe being interested in and specialising in science as a process of 'enculturation' of individuals to the specific culture - or even 'subculture' - of science (Aikenhead, 2001; Krogh & Thomson, 2005; Lyons, 2006; Wenger, 1999). The specific features of this science culture seem to reduce young people's willingness to associate with it: studies on the perception of science in student populations and among the general public found descriptions of the science culture to be more negative than positive, a finding that matches and might explain the negative attitudes towards and lack of interest in science encountered in many countries (for overviews see Driver, Leach, Millar, & Scott, 1996; Driver, Newton, & Osborne, 2000; Kessels, Rau, & Hannover, 2006; Lederman, 1992; Osborne, Simon, & Collins, 2003; Schreiner, 2006; Sjøberg, 2002). Summarizing just the keywords of that research, students see school science as 'dull, authoritarian, abstract, theoretical, fact-oriented and fact-overloaded, with little room for fantasy, creativity, enjoyment, and curiosity', 'difficult and hard to understand' (Sjøberg, 2002, cited in Schreiner, 2006, p. 57), and unfeminine (Kessels et al., 2006).

The process of enculturation into the science culture involves the acquisition not only of knowledge and skills, but also of values, beliefs, expectations, communicative codes, conventional actions (i.e. performing experiments), and attitudes that are part of the science culture (Aikenhead, 1996). Consistent with this, a study of Danish students identified the 'feeling' and 'reputation' associated with science as important factors in choosing science as a major (Krogh & Thomson, 2005). As Krogh and Thomson (2005, p. 238) put it, "learning is a process of culture-acquisition, where students get to know and practice the 'ways of seeing', 'ways of talking' and 'ways of doing' characteristic for the science class specific subculture." What this means is that entering into and adapting to that specific subculture seems to involve a science-specific way of being and thinking that affects many aspects of a learner's identity.

Becoming part of that science culture has been described as a kind of 'cultural border-crossing' (Aikenhead, 1996) that can be more or less hazardous. Just *how* hazardous depends on the perceived mismatch between students' other existing life worlds of family and peers, on the one hand, and the science culture, on the other hand.

Our work is based on the notion that the decision to specialize in science during secondary education depends not only on issues that are directly linked to science teaching itself, but also on characteristics of the culture of science in a broader sense. We expect that choosing science is a matter of perceived congruence between the science subculture and one's identity.

Science culture and adolescents' identity

The process of enculturation into the subculture of science - and the refusal to be introduced to that very subculture - has been linked to the identity development of learners. Recently, Schreiner (2006; see also Schreiner & Sjøberg, 2007) proposed relating the lack of interest in science in developed countries to the specific identity-formation process in late modern societies. In the following, some parts of her argument are summarized. The 'late modern zeitgeist' can be highlighted with the key words of detraditionalization, cultural liberation, risks, reflexivity, individualization, and, most important and resulting from many of the previous concepts, active identity construction (Schreiner, 2006, p. 36). While in traditional modern societies biographies were conceived as the result largely of classical structures such as family, social class, and local society, in late modern societies identity formation has become an individual's personal 'project' requiring deliberate effort. Identity is seen as managed through one's personal reflexive choices (Côté, 1996). These choices are related to everyday matters like clothes, taste in music, sports, beliefs, etc. (Giddens, 1991), and also to school and classroom matters. Learning activities, subject preferences, and choices are seen as a process involved in a person's identity development (Wenger, 1999).

Schreiner (2006; and Schreiner & Sjøberg, 2007) concludes that most young people in late modern societies, especially females, choose to have an identity that is not connected to science and the culture of science. A main reason for this is seen in the features of the culture of science (as described above) that clash with most students' identity projects, since the identity projects usually pursued in late modern societies are centred around the idea of self-realisation. The idea of wanting to be 'useful' or 'obedient' no longer serves as a guideline for one's biography. Rather, subjective well-being, leisure, friends, developing oneself and one's personal talents are conceived as important, as is the search for the meaning of life and happiness (e.g. Layard, 2005). Since school science is perceived as not allowing room for self-realisation or intellectual freedom, but is associated with heteronomy, involvement in science does not fulfil adolescents' need to develop their own set of values and their identity at large (Kessels et al., 2006).

Self-to-prototype matching: How identity and culture meet

A more psychological than sociological approach was advanced by Hannover and Kessels, who also emphasize that a crucial factor for why students turn away from science is the mismatch between their image of science and most students' identity or self (e.g. Hannover & Kessels, 2004; Kessels, 2005; Kessels et al., 2006). In several studies, they applied the self-to-prototype matching theory (Burke & Reitzes, 1981; Niedenthal, Cantor & Kihlstrom, 1985; Setterlund & Niedenthal, 1993) to students' liking of school subjects. A prototype means a cognitive representation of a typical, average, or modal 'best example' (Rosch, 1973). Niedenthal and colleagues proposed that when making a self-relevant decision, people compare their self-image to the prototype that chooses each of the options in question and eventually select the option with the greatest similarity between self and prototype. In other words, the matching of prototype and self is used as a heuristic when people have to choose one of several available options. Niedenthal et al. suggest that people tend to act in this way in order to conserve or preferably strengthen their self-image when making self-relevant decisions that actually or symbolically involve entering a specific social context. Adolescents in particular may search for situations in which they can elicit self-verifying feedback with respect to the characteristics they ascribe or want to ascribe to themselves (Ruble, 1994; Hannover, 1998). This implies that they prefer to belong to groups, communities, or cultures whose perceived typical member fits their self-image.

Hannover and Kessels (2004) found that German secondary school students' liking of school subjects was stronger, the more similar their description of the prototypical peer favouring a particular subject was to their own self-image. They were able to show that the prototypical peer who favours science was highly incompatible to most students' self-image, and was seen to possess relatively more negative traits than a prototypical peer who favours languages. Specifically, the science prototype was described as being less physically and socially attractive, less socially competent and integrated, less creative and emotional, but at the same time as more intelligent and motivated than peers who prefer languages. The relevance of the self-to-prototype matching procedure was further emphasized in a study where students described both the prototypes and the self by using exclusively masculine (instrumental) and feminine (expressive) traits (Kessels, 2005); this study also found that intended career choices could be predicted with the perceived distance between self and prototype (Kessels & Hannover, 2002). As a consequence, Hannover and Kessels maintain that the incompatibility of the science prototype to students' self-identity is in fact a crucial factor why students do not wish to specialise in science.

In the present study, we want to extend previous findings from the German study both by studying the prototypes for different subjects in the Netherlands, and by predicting actual *choices* of science on the basis of the perceived fit between the self and the science prototype.

Study overview and hypotheses

The present study tackles three larger research questions. In a first step, we wanted to compare data gathered from Dutch students with the data from German students (the latter published in 2004). Specifically, we wanted to test whether Dutch and German students perceive the prototypes of different school subjects in a similar or different way, and whether the perceived distances between these prototypes and students' self-image differ in the Dutch and German sample. Since both Germany and the Netherlands face a shortage of students wanting to choose majors related to a career in the field of S&E (OECD 2005), and since students in both countries prefer school subjects related to the humanities over subjects related to science, some similarities should exist: we expected that the *relatively more negative* and the *relatively more self-incongruent* perception of typical students favouring science compared to typical students favouring humanities that was found in the German sample would also be found in the Dutch sample. In addition, we wanted to directly compare Dutch and German students' perception of the typical peer favouring science and the distance between their self-descriptions and the description of the prototype. Even if students from both countries conceive of themselves as more similar to a typical student favouring humanities than to one favouring science, the absolute perception of the prototypes and the similarity of self and science prototype could differ in the two countries.

In a second step, the present study set out to test not only whether the self-to-prototype theory is a useful tool for predicting the *liking* of different school subjects (Hannover and Kessels, 2004; Kessels, 2005) and the *wish to pursue a career* in different fields (Kessels & Hannover, 2002), but also whether the *actual choices* students make during their secondary school are related the perceived fit between students' self-image and the prototype. As Dutch students have to choose different academic 'profiles' during 9th grade, they make a particularly appropriate sample to test this hypothesis. Following the procedure in the studies by Hannover and Kessels, we expected that only students who have a sufficiently clear and stable image of themselves can actually make use of the self-to-prototype matching strategy in order to direct their interests.

In a third step, we wanted to put the self-to-prototype matching hypothesis to a thorough test. Our assumption is that the self-to-prototype-matching is an independent factor for explaining academic preferences and choices. We tested whether the distance scores between students' self and the prototypes would still be able to explain variance in choice of profile when controlling for other variables that are relevant predictors for these choices according to the extant literature (e.g. van Langen, 2005). More precisely, we tested whether the self-prototype-distance score would still be related to profile choice even if students' gender and grades were controlled for.

In addition, we set out to separate the effect of self-to-prototype matching from other possible links between personal traits and subject choices. Some students might possess traits that fit the common image of science better than others. Much in the same way that tall people will do better in basketball and may therefore feel more inclined to choose it as their sport, the common image of science *activities* may attract introverted people.

In our study, we eventually used the similarity of one's self and the *exclusively subjective image of peers liking science* to predict the choice of the science profile. Going beyond the study of Hannover and Kessels (2004), we provide an additional analysis for predicting the choice of science in which we first controlled for the influence of those traits that are commonly assumed to be related to science choices. In this way we tried to eliminate explicitly the socially shared 'image factor' within the subjective perception of typical peers liking science. Thus, we tested whether self-to-prototype matching is relevant for students' choices in a way that goes further than predicting whether tall people are more likely than short people to play basketball.

Method

Participants

The study comprised 54 Dutch 9th-grade students; 26 students from general higher secondary education (‘havo’), and 28 students from pre-university education (‘vwo’). These students are 14 or 15 years old and are currently deciding on their so-called ‘profile’. In Dutch secondary education, choosing a profile means that students have to make decisions about which subjects/classes they want to attend (and which subjects they will not continue). This decision has a major impact, because is directly related to possibilities for entering higher education. As a consequence, this choice determines whether or not students can pursue a science-related career. One of the following four profiles has to be chosen:

- N&T = nature and technology (compulsory key subject: level 2 physics),
- N&G = nature and health (compulsory key subject: biology),
- E&M = economy and society (compulsory key subject: economics),
- C&M = culture and society (compulsory key subjects: 2 foreign languages)

N&T and N&G are science-oriented profiles and are necessary for science-related studies. Within each profile there are compulsory classes (i.e. level 2 physics for the science profiles) and optional classes.

Instruments

Written questionnaires were used. The respondents were first asked to rank the eleven school subjects according to their personal preference. The subject the student liked best received 11 points; the subject the student liked least, 1 point. Moreover, students were asked to indicate their mean grade for each school subject. They were then asked to reveal the profile of their choice, or if still undecided, their first and second choices. They were also asked to give their arguments for choosing or preferring a profile.

The main part of the questionnaire was a translation of the questionnaire previously designed and used by Hannover and Kessels (2004). The authors had used the results of four different pilot studies for developing an instrument that can be used for describing prototypes liking different school subjects: First, eighth and tenth graders had been asked to generate trait adjectives that described boys or girls of their age, second, seventh graders had been asked to describe several school subject "as if they were a person", third, eleven to thirteen graders had been asked to write essays about the typical student who is successful in German, English, math, or physics, fourth, in-depth interviews on the topic of prototypes about school subjects were conducted with five teachers (Hannover & Kessels, 2001). From these pilot studies, Hannover and Kessels derived a list of 65 trait adjectives for the instrument used in the German 2004 study. For the Dutch study, the items were first translated from German into Dutch, and than translated back into German by another person. The few resulting differences were clarified with the German authors of the questionnaire

In our study 'prototypical peers' favouring different school subjects had to be described using the 65 trait adjectives. Each participant had to describe prototypes for physics, biology, economics, and foreign languages (female participants had to describe female prototypes and male participants had to describe male prototypes). These subjects are compulsory and representative for each of the four profiles.

Subsequently, respondents were asked to fill in the Self-Clarity-Questionnaire by Campbell, Trapnell, Heine, Katz, Lavallee, and Lehman (1996), which would allow for the selection of respondents with high self-clarity who are expected to make use of self-to-prototype matching when making decisions. Finally, the students were asked to describe themselves using the same 65 trait adjectives they had used to rate the prototypes.

Results

The study comprised 54 students. The school subjects ranking data of two respondents were incomplete. Two other respondents were rejected from the main analysis due to incomplete data. Another respondent was repeating 9^{th} grade and was choosing a profile for the second time. He was also rejected for the main analysis. In total, the analysis of the ranking data comprised 52 cases, while the main analysis comprised 51 complete sets of data. Our data are presented in combination with data gathered by Hannover and Kessels (2004) in order to test for cross-cultural differences.

Preference for the school subjects

Analysis of the ranking of school subjects revealed that physics and chemistry were the least popular. Physics, in particular, was significantly less popular than all other subjects (the mean rank for physics is significantly lower than that of the second-worst subject, chemistry, $t=2.2$ $p< 0.05$). This corresponds with the students' mean grades: the grades for physics were significantly lower than for all other subjects (the mean grade was significantly lower than that of the next 'worst scored subject', history, $t=2.5$ $p< 0.05$).

Multidimensional scaling using PROXCAL from the SPSS-package (Meulman & Heiser, 2001) was performed on the ordinal ranking values. Figure 1 shows two-dimensional MDS solution, which is acceptable (stress II = 0.15; D.A.F. = 0.99). The least-liked subjects are found on the right; the most-liked subjects are found on the left. Hence Figure 1 shows that one dimension accounting predominantly for our students' preference is the science – humanities polarity.

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Insert Figure 1 about here

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Perceived traits characterizing the prototypes of students preferring the school subjects

In order to describe the traits for peers liking each of the school subjects, factor analysis was used to organize our data and arrive at a compact description. The factor-structure appeared to be essentially the same as the one found by Hannover and Kessels (2004). To allow for a comparison of our results to the results of Hannover and Kessels, we chose to use the factors found and validated by Hannover and Kessels, since these were based on a larger sample. The 65 personality traits were grouped into five factors:

1. physical and social attractiveness
2. social competence and integration
3. intelligence and motivation
4. arrogance and self-centeredness
5. creativity and emotions

The factors found by Hannover and Kessels turned out to be sufficiently reliable in our case too (Table 1). There was one exception: an alpha of .50 was found for the scale 'Arrogance and self-centeredness'.

Table 1 presents an overview of the scales used and the scores on the scales, representing the *self- descriptions* of the Dutch students.

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Figure 2 shows the scores on each of the five subscales for prototypes preferring each of the four school subjects as well as the students' self image.

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Insert Figure 2 about here

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A multivariate analysis with the scales as dependent variables and the school subjects as factors revealed that all factors except for ‘arrogance and self-centeredness’ depend significantly on ‘subject’, with F-values ranging from $F\ (3, 51) = 5.4$ ($p < .001$) to $F\ (3, 51) = 14.14$ ($p < .000$). On all scales except ‘arrogance and self-centeredness’, the self image of the students is significantly closer to the humanities prototypes than it is to the science prototypes (significant t-values ($p < .01$) found are t=5.7, t=4.8, t=4.0, t=3.0, respectively).

It also illustrates that the prototype of peers favouring physics shows a relative lack (as compared to the self description) of ‘Physical and social attractiveness’, ‘Social competence and integration’, and ‘Creativity and emotions’, while the prototype of peers favouring physics is considered more ‘intelligent and motivated’. Students’ t-tests revealed that these differences are statistically significant (Table 2) and associated with moderate to strong effects (Cohen’s $d > .7$).

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Insert Table 2 about here

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Table 2 also compares the Dutch and German prototypes of peer favouring physics. The German physics prototype differs significantly from the German self-image on all 5 scales. All differences were in the same direction but are stronger than those found for the Dutch students.

When taking the mean of science subjects (Physics and Biology) and of humanities subjects (Economics and languages) for the Dutch students, factor scores for Science and humanities were calculated. A t-test analysis shows significant differences in the means for all scale values between science and humanities in both countries, as can be seen in Table 3. The t-values have the same sign and roughly the same values for the Dutch sample as for the German sample of Hannover and Kessels (2004), even though we used different subjects than those used by Hannover and Kessels.

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Calculating distance measures

For each of the four profiles, we calculated the perceived distance between the prototype of a peer liking a profile's key subject and the self-image making concrete the very idea of prototype matching theory. Both a squared Euclidean distance (the sum of the *squared* differences between the self and the subject score on each of the 65 items) and a city-block distance (the sum of the *absolute* differences between the self and the subject score on each of the 65 items) were calculated. These proved to correlate very strongly ($r \geq .988$). We therefore used the city-block approach that was also used by Hannover and Kessels (2004) and checked whether our key findings could be reproduced using the squared Euclidean measure.

From the four prototype-to-self distances (hereafter referred to as 'physics distance' for the distance between physics prototype and self) we calculated the *science distance* (mean of physics and biology distance) and the *humanities distance* (mean of economics and foreign language distance). The humanities distance and sciences distance mutually correlate (r =.63, p< .001).

Inspired by the above result that the liking of school subjects depended on only one dimension (the science-humanities polarity), we computed the *science-humanities distance* using the formula (science distance - humanities distance)/2. In addition, the *total distance* was calculated as (science distance + humanities distance)/2.

Finally, the *expected profile* was calculated. This is the profile for which the lowest subject distance for the key subject was found, i.e. the profile for which the key subject-prototype was described by a participant as being most similar to his or her self. In a few cases the subject distances for two subjects were identical. In such cases, the tie was resolved by taking the profile in the sector with the lowest science-humanities distance as the 'expected profile' (e.g. if the tie was between the E&M-profile (humanities) and the N&G-profile (science), and the distance to the T&N-profile (also science) was *smaller* than to the C&M-profile (also humanities), the N&G-profile was selected as the 'expected profile').

Correlation with sector appreciation and choice

Table 4 shows the Spearman rank correlation coefficients of the science-humanities distance with the profile chosen. In this calculation the profiles are ranked along a science – humanities scale running from N&T (the most science-oriented profile) via N&G and E&M to C&M (least science-oriented profile). Table 4 also shows the t-values for the relation between the science-humanities distance and the sector (i.e. science or humanities) of the profile of the students' choice. For high self-clarity students, strong significant correlations were found, whereas no significant values were found for students with low self-clarity. These results are found when considering the *preferred* profile as well as when considering the profile *chosen*. For the latter, a particularly high value was found, corresponding to almost 50% explained variance for the high self-clarity students.

For all students (low and high in self-clarity) and the sector of the chosen profile a correlation of r_s .33, p< .05 was found which corresponds to an explained variance of only about 10%.

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Relation of the self-to-prototype distance scores to profile choice

On the level of individual profiles and focussing on high self-clarity students only, an attempt can be made to test whether a low (high) score for a particular self-to-subject distance adequately predicts that the corresponding profile is (not) chosen. Crosstabs analysis was used to calculate Cohen's kappa as a measure for agreement between the predicted profile – that is the profile for which the lowest self-to-subject distance was found for the key subject - and the profile actually chosen. A moderate value (κ =.44; p< .0001) was found for respondents with high self-clarity. As expected, no significant kappa value was found for low self-clarity subjects.

From the complete matrix shown in Table 5, it is clear that the E&M profile is fairly predictable, while the C&M profile is moderately predictable.

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The analysis revealed that the N&T and N&G profiles are difficult to predict. However, when taking into account the science-humanities polarity found in the MDS reported above, and therefore collapsing the N&T and the N&G profiles into one category of 'science profiles', this category appears moderately predictable (67% of the predictions are correct) as well, and a higher value of Kappa (κ =.53; p< .001) was found.

Kappa represents a conservative view on the predictability of profile choice out of matching data, since most false predictions tend to concentrate in profiles adjacent to the predicted profile. Also, the profile actually chosen has the next smallest value of self-to-subject matching in 60% of the false predictions.

Robustness of the correlation of science-humanities distance to sector choice

In order to test the robustness of the correlation of science-humanities distance to sector choice, a series of ANOVA tests was run, all using the sector of the profile chosen as a dependent variable, and the science-humanities distance as a covariate. When adding 'grades' – a well known variable influencing profile choice – as a second covariate, no significant cross effect was found, while the effect of science-humanities distance (matching) remained significant. The same was true when adding 'gender' – another factor known for its influence on profile choice – as a factor. In both cases the effect attributed to science-humanities distance remained clearly present and values of at least F (1, 25) = 5.1 (p< .05) were found.

Direct effects of personal traits: putting the matching hypothesis to a test

To test whether or not the effect could be a result of the fit between students and the subject as such (e.g. the aims and activities it involves) and the students' personality, we defined the variable 'science inclination' by combining all traits in the self-image that correlate to choosing a profile in either the science sector or the humanities sector. The factor 'science inclination' includes high values for the traits 'lonely' and 'dry', and low values for the traits 'open-minded', 'talkative', 'emotionally sensitive', 'garrulous', 'outgoing', 'appreciates clothes', 'smart-alecky', 'open', 'sensual', 'spontaneous', 'sparkling', 'opinionated', and 'witty'. It can be typified as 'less socially oriented'.

As expected, 'science inclination' correlated significantly with the sector of the profile chosen (r = .62, p< .001). An analysis of variance was performed using the sector of the profile chosen as a dependent variable and the science-humanities distance and 'science inclination' as covariates. Again, the simultaneous model was used. Though a near significant effect was found for 'science inclination' (F (1, 25) = 3.7 with an alpha of .068), the effect of science-humanities distance remained clearly present with F (1, 25) = 5.7 (p< .05).

Conclusion and Discussion

Our results indicate that Dutch students see typical peers who favour science subjects (physics/ biology) as less attractive, less popular and socially competent, less creative and emotional, and more intelligent and motivated than typical peers who favour humanities subjects (economics/ languages). Thus, the relatively more negative perception of typical peers who favour science compared to peers who favour humanities that was reported in the German study by Hannover and Kessels was found for Dutch students, as well. In addition, Dutch students likewise conceive of themselves as being less similar to the science prototype than to the humanities prototype. However, a direct comparison of the absolute description of the physics prototype, which was the focus in both studies, seems to indicate that Dutch students have a somewhat more positive view of the typical student who likes physics. Similarly, although Dutch students feel themselves to be different from the physics prototype, they do so to a lesser extent than their German counterparts. How might one explain these differential findings? First, they could be due to the measurement tool used. The scale for prototype description had been developed using results from pilot studies in Germany. Although we were able to replicate the factor structure and also the direction of the results on each of the subscales in the Dutch sample, it is still reasonable to assume that the instrument is unbalanced with respect to the emphasis put on particular traits by subjects in the two countries. In fact, it is conceivable that pilot studies in the Netherlands might have suggested the usage of some other trait adjectives for the prototype description. However, apart from a differential functioning of the scale used, the findings could reflect some existing differences between Dutch and German students' image of science. For instance, the PISA study in 2003 (PISA, 2003) revealed important differences between the Netherlands and Germany with respect to performance: while Dutch students were in the top achievement group in both mathematics and science, the performance by German students' performance only matched the OECD average. There are also differences in the curricula and in the pedagogical approaches to the training of teachers (Eurydice, 2006).

Still, most Dutch students, irrespective of their higher performance level internationally, do not wish to pursue a career in science. Our study has shown that Dutch students still feel that subjects from the humanities are better suited to them than science subjects. This finding emphasizes the relevance of the *relatively* more negative and the *relatively* more self-incongruent perception of the science prototype (compared to the humanities prototypes) for educational and vocational choices. As students are asked to choose between different alternatives during their academic career, they will still opt for those subjects they feel themselves most similar to.

As expected, we found that the *actual choice of a specific academic profile* could be predicted by students' perceived similarity between their self and the respective prototypes. Thus, we were able to extend the findings that students' subject liking (Hannover & Kessels, 2004; Kessels, 2005) and their intended career choices (Kessels & Hannover, 2002) depend on the perceived match between self and prototype. In line with these previous findings, we found very strong correlations between profile choice and self-to-prototype distance scores for those students who reported a relatively stable and clear self-image, while students low in self-clarity could not make use of the matching strategy to direct their academic choices. This finding substantiates the asserted mechanism of the self-to-prototype matching theory, as it shows that it is not merely the negativity of the prototype itself that leads students to turn away from science, but that the perceived *mismatch* between self-image and the image the prototype also signals students not to pursue science.

We put the self-to-prototype matching hypothesis further to the test in additional analyses. We were able to show that the profile choice was predicted by the perceived distance between self and prototypes even if grades and gender had been controlled for. This indicates that self-to-prototype matching is an essential factor for explaining the remaining variance in academic choices that is not explained by other well-known predictors such as gender and grades.

A second analysis also aimed at tackling the question of how much actual *self-to-peer-prototype* matching is involved in students' academic choices if other factors are held constant. To that end, we controlled statistically for all traits that were considered unequivocally typical for students who like science. Thus, we eliminated the impact of those personal traits that represent a kind of 'science inclination'. It is reasonable to expect that the common image of science, its *activities in particular,* will attract people who possess characteristics that suit the assumed demands of the science domain (like the stereotype of introverted persons who can get absorbed by a theoretical problem for long hours without needing any human company). By eliminating explicitly these traits, our analysis focused on a pure self-to-prototype matching score, this way extending evidence from the extant literature on the relationship between personality dimensions on the one hand and vocational choices on the other hand (mostly referring to Holland's (1992) model of vocational interest types (the RIASEC model), e.g. Tokar & Swanson (1995); see Barrick, Mount & Gupta (2003) for an overview)). We found that even if we controlled explicitly for those traits that were consistently related to 'science inclination', students' academic choices were still dependent on their perception of similarity between their self and their science-liking peer-prototype. Hence, the matching process seems to be an important social psychological factor for explaining academic choices beyond one's diagnosis of individual suitability for science.

Taken together, our findings show that the way typical peers who favour science are perceived can be linked to a specific culture of science that involves a certain way of being and possesses specific personality traits. The features of this specific culture of science have been described by various authors (Driver et al., 1996; Driver, Newton & Osborne et al., 2000; Merton, 1973; Fox-Keller, 1986; Kessels et al., 2006; Lederman, 1992; Osborne Simon, S., & Collins, et al., 2003; Schreiner, 2006; Sjøberg, 2002; Traweek, 1992). It comprises elements historically rooted or functional within classical academic scientific practice: a certain kind of masculinity (or more precisely, non-femininity), a preference for the conveying of content rather than the process of communication, a tendency to be rational and to put emphasis on rational explanation over emotional aspects of communication, a tendency to make things technically objective wherever possible, and a tendency to refrain from placing emphasis on personal presentation. Further, the perception of this culture by students drew a picture of science as ‘dull, authoritarian, abstract, theoretical, fact-oriented and fact overloaded, with little room for fantasy, creativity, enjoyment, and curiosity’ (Sjøberg, 2002, cited in Schreiner, 2006, p. 57), and at the same time as ‘hard and difficult to understand’. The traits that were found in both the German and Dutch samples as typifying the science prototype fit very well into this picture.

We would like to emphasize that we are not advocating the idea that science ‘by its nature’ necessarily appeals to a particular kind of student whose personality just fits the subject’s content and approach. However, teaching science does involve the reproduction of science culture as it is presented in the classroom. This process encompasses not only learning about science in general, it also leads to a self-selection favouring those students who feel they fit well into the science culture, since they are able to cross more easily the border demarcating science from other life worlds. For most students, however, this cultural gap seems to be quite large, which seems to add greatly to the low popularity of science, especially physics (Aikenhead, 2001; Costa, 1995; Krogh & Thomsen, 2005; Munby, Cunningham & Lock, 2000). Our data indicate that a self-selection with reference to specific personality traits within a social perspective does in fact occur, and that this process of self-selection functions by self-to-prototype matching. Selection is not confined to selection on the basis of perceived or actual competence or an appreciation of the aims or activities associated with science. Our study has shown the relevance of this matching process for students' academic choices; and as these profile choices largely determine which subjects a student can enrol in at university, the perceived match of one's self and a specific domain culture has an important impact on young people's careers. In order to improve science education and to attract more students to science subjects, we need to identify successful ways that allow cultural border crossing for students with less 'science-oriented' identities.

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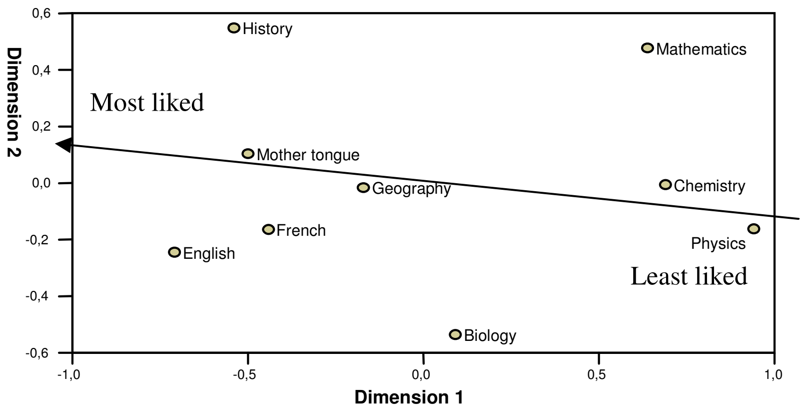
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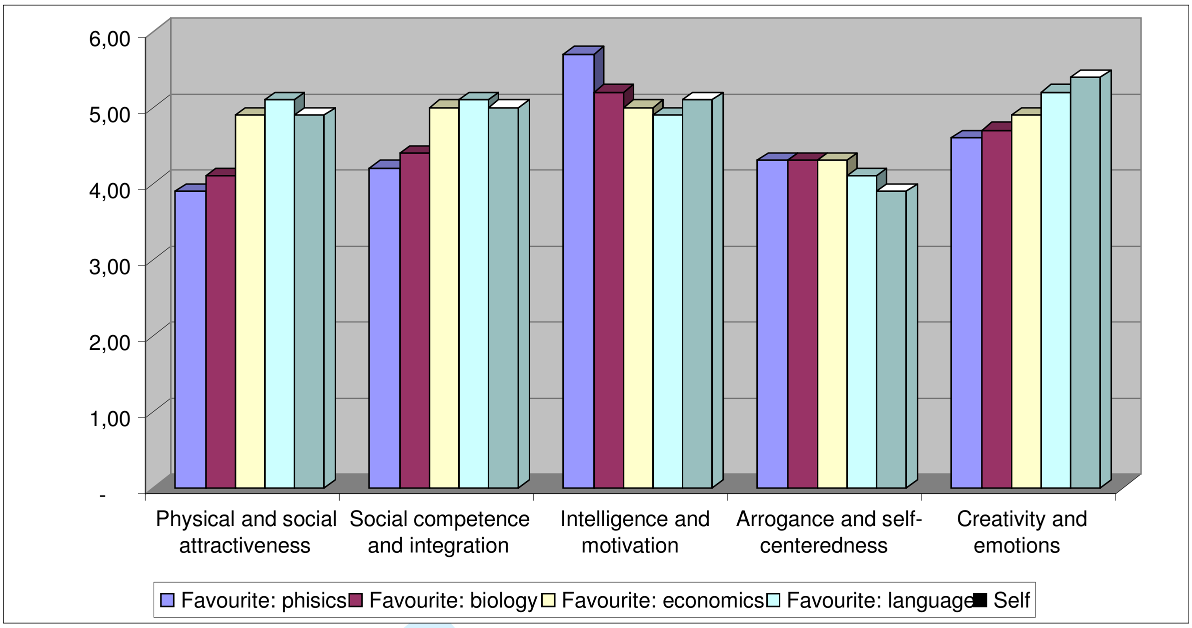
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Physical and social attractiveness
Social competence and integration
Intelligence and motivation
Arrogance and self-centeredness
Creativity and emotions
Favourite: phisics
Favourite: biology
Favourite: economics
Favourite: language
Self

	α	All	High self clarity
		(n=51)	(n=26)
1. Physical and social attractiveness	*.96*	4.95(1.16)	5.0(1.20)
2. Social competence and integration	*.94*	5.01(1.14)	5.2(1.26)
3. Intelligence and motivation	*.88*	5.09(1.05)	5.2(1.06)
4. Arrogance and self-centeredness	*.50*	3.90(.74)	3.8(.71)
5. Creativity and emotions	*.87*	5.43(1.03)	5.4(1.02)
		4.5	4.8

	Netherlands	Germany	Comparison	Comparison of physics to self (high self clarity)			
				Netherlands		Germany	
	(n=50)	(n=53)	ad hoc t-test	t-test	Effect size (Cohen's *d*)	t-test	Effect size (Cohen's *d*)
1. Physical and social attractiveness	3.88(1.36)	3.27(1.09)	2.53**	-3.54***	-0.87	-8.15***	-1.61
2. Social competence and integration	4.25(1.14)	3.85(.93)	-1.96	-3.32**	-0.79	-8.24***	-1.63
3. Intelligence and motivation	5.57(.77)	5.81(1.01)	-1.35	1.74	.40	3.10**	.62
4. Arrogance and self-centeredness	4.29(.70)	4.43(.91)	-.87	2.88**	.70	7.94***	1.57
5. Creativity and emotions	4.64(1.00)	4.15(.83)	2.71**	-3.12**	-75	-4.77***	-1.09

	The Netherlands (this study)			**Germany (Hannover & Kessels, 2004)**		
	Science (n=50)	Humanities (n=50)	t-test (n=50)	Science (n=53)	Humanities (n=53)	t-test (n=53)
1. Physical and social attractiveness (16)	4.0(1.04)	4.5(.99)	**-5.7****	3.46	4.43	**-5,59*****
2. Social competence and integration (18)	4.3(.88)	5.1(.69)	**-4.8****	3.96	4.87	**-6,81*****
3. Intelligence and motivation (10)	5.5(.66)	5.0(.70)	**4.0****	5.88	5.29	**4,61*****
4. Arrogance and self-centeredness (9)	4.3(.60)	4.2(.70)	**.78**	4.42	4.06	**2.77****
5. Creativity and emotions (10)	4.7(.87)	5.1(.75)	**-3.0****	4.14	4.72	**-4,65*****
	4.5	4.8		4.4	4.7	

	Profile (Spearman r_s)		Sector (science / hum.) (t)	
	Appreciated	Appreciated	Appreciated	Chosen
High self clarity (n=26)	.43*	.55**	3.32**	4.80***
Low self clarity (n=22)	.02	.06	1.12	1.54

		Predicted profile				
		N&T	N&G	E&M	C&M	Total
Profile Chosen	N&T	1	0	0	1	2
	N&G	2	1	0	2	5
	E&M	0	2	9	2	13
	C&M	0	0	1	5	6
Total		3	3	10	10	26
Percentage of predictions that is correct		33%	33%	90%	50%	