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Scientists, Their Work, and how Others Perceive Them: Self-Perceptions of Scientists and Students' Stereotypes

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Abstract

Stereotypes are simplifications of complex characteristics of groups of persons and are common and widespread through media as well as everyday experiences. Especially regarding occupational groups stereotypes can be a problem because many young people base their occupational choices on these simplified conceptions. It is thus important to comprehensively depict scientists´ fields of activities. Therefore, we categorized typical scientific activities into the so-called RIASEC+N dimensions. Based on these dimensions, we investigated the self-perceptions of junior scientists ($n = 92$) and professors ($n = 10$) about their own work and compared these perceptions with the perceptions of school students ranging from grades 10 – 13 ($n = 244$). The results show differences between some scientific activity fields for the three groups. For example, students tend to underestimate creative and social aspects of typical scientists´ work fields and hold rather stereotypical views. Thus, interventions to promote an authentic image of science are needed.

Keywords

Nature of scientific inquiry, vocational fields, stereotypes

1 Motivation

When people are asked to think of a "typical scientist", they often describe incomplete or simply wrong notions. They typically associate scientists with a "man in a white lab coat with a beard. He is presumed to work in a laboratory all day, is intelligent, always busy and his work is possibly dangerous." (Höttecke, 2004; Tintori & Palomba, 2017; Höttecke & Hopf, 2018) – Even though of course, the field of science and scientists is much more diverse. Furthermore, researchers and scientists are mostly associated with STEM, yet there are many researchers in other fields such as historians, linguists, or economists. Such stereotypical conceptions of scientists might stem from everyday experiences, as well as media, such as films, televisions and comics (Driver et al., 1996). A closer examination shows that there is more than one stereotype and also mixed versions of these defined types (Solomon, Scott & Duveen, 1994; Stamer et al., 2019). Most of the described stereotypes include aspects typical for working in a laboratory, such as performing experiments, working with special devices and wearing safety clothes. These aspects are definitely not wrong and the following questions arise: Why are these conceptions not complete; which other aspects are typical for scientists, and why should it be important to have a wide ranged and authentic concept about science?

Answering the last question is of great importance, because no further efforts would be necessary without an answer of this question. Thus, Driver et al. (1996) summarised the five most important arguments provided by Thomas and Durant (1987) as to why promoting public understanding of science is important. These arguments have a moral, cultural, democratic,

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utilitarian, and an economical background. In the presented study we focus on the last point, the need for qualified scientists in the future. Today's literature provides evidence that the stereotypes described above have a huge influence regarding occupational choices (Tintori & Palomba, 2017). Studies by Hannover and Kessels (2002) show that students (physics and engineering), having a clear self-perception, choose their preferences and make their occupational choices dependent on the similarity of their self-perceptions with their stereotypical conceptions, apart from further influences such as hereditary, cultural and professional aspects (Holland,1959).

Consequently, incomplete notions about science could be a problem because only a limited number of people – those who can identify with the stereotype – are attracted to these incomplete and simplified stereotypical descriptions of science. This is only one reason why it is necessary to convey an authentic and complete concept of science, especially regarding occupation-related aspects. Also noteworthy, studies showed no consistent findings about students' states of knowledge regarding science (Werner & Kremer, 2010; Solomon, Scott & Duveen, 1994). However, before assessing the notions of students, the question needs to be answered if the work of a scientist includes other important aspects in addition to the stereotypical aspects. Here, one should consider the constructs about the scientific knowledge and scientific processes. Science educators have thought about the *nature of science* (NOS) (e.g. Aikenhead, 1987, Jung 1979, Kuhn 1991, Kircher 1995 and Kircher and Dittmer 2004) for decades. However, the definition and dimensionality of NOS varies in literature and no consistent definition exists (Neumann & Kremer, 2013). In general, NOS describes the scientific knowledge or rather the product of inquiry. Lederman (2007) listed NOS aspects such as the temporary character of science, the relevance for the culture and the creative component of science. However, these aspects only describe the product of scientific processes. In comparison, the scientific processes, "how" the knowledge is generated and accepted, are described through the construct *nature of scientific inquiry* (NOSI). Based on this construct Schwartz, Lederman & Lederman (2008) and Neumann (2011) have published aspects such as designing research questions, methods suitable for investigations and evaluations, or interpreting data. Yet, prior scientific knowledge (NOS) is necessary to generate new scientific knowledge (NOSI). Therefore, aspects of both constructs overlap, and often NOS and NOSI are conflated. Nevertheless, one must differentiate between them. The distinction is further supported by the National Science Education Standards (NSES, 1996) (Lederman, 2007; Schwartz, Lederman & Lederman, 2008).

Although there are differences between NOS and NOSI, both constructs describe the diversity of science and also different focal points, such as creative, social and craft aspects. Most of these scientific activities can also be transferred to other fields of research such as science of history, archaeology or linguistics, for which stereotypical, incomplete conceptions also exist (Henson, 2012; Kessels et al., 2006). Henson (2012) describes the "dumbing down" of historians and archaeologists on television and justifies this through the desired fitting into an entertainment format so that archaeology series for example include interesting processes such as excavations and reconstructions instead of allowing objective, critical re-evaluations of the results. Kessels et al. (2006) measured the implicit association of school students (11^{th} grade) with physics compared to English. The Implicit Association Test (IAT) showed that students associate physics (relative to English) more easily with words referring to difficulty (than to ease), to males (than to females), to heteronomy (than to self-realization), to others (relative to words referring to self) and to unpleasantness (relative to pleasant words).

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With this background, we know that there are other scientific aspects relevant for changing the stereotypical conceptions of science and for fostering a more accurate view, especially regarding occupational choices. When choosing a profession, one thinks about what the profession includes, or rather what kind of activities it contains. That is why our presented study focuses on typical scientific activities. Furthermore, as described above, individuals identify with their (future) occupational field. Hence, it is important to collect and categorise a wide range of typical activities to assess the students' notions of science.

2 Theoretical background

To categorise the collected activities we decided to use the RIASEC+N model. This model originally descended from the already well-established RIASEC model, which was developed by Holland (1997) for the subject area of vocational choices. Holland classified a large number of professional possibilities into specific fields of interests, the so called RIASEC dimensions. The aim of his research is to explain vocational behaviour, help people select or change their profession and finally attain vocational satisfaction. Within the RIASEC model, different professions were sorted into the six vocational RIASEC orientations, whereby every letter of the acronym RIASEC stands for one specific vocational field. Table 1 shows all RIASEC dimensions with a description of the professions associated to the respective dimension.

Table 1. Overview of Holland's RIASEC Dimensions (1997) in Comparison to the RIASEC+N Dimensions by Wentorf, Höffler & Parchmann (2015)

Dimension	Acronym	Type of activity	Example profession (by Holland)	Example activity of scientists (by Wentorf et al.)
Realistic	R	Handicraft	Carpenter	Performing measurements
Investigative	I	Intellectual	Scientist	Interpreting data
Artistic	A	Creative	Actor	Developing research ideas
Social	S	Helping	Teacher	Supervising students
Enterprising	E	Managing	Politician	Guiding working groups
Conventional	C	Administrative; meticulous	Secretary	Doing administrative tasks
Networking	N	Collaborative	-	Interacting with scientists from other universities

For instance, the R stands for the dimension *Realistic* and includes professions such as craftsmen who "work with their hands"; the I is standing for the *Investigative* dimension including professions such as scientists who "work with their head". Taking a closer look at the

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everyday activities of scientists, this vocational field should not only fall into the dimension *Investigative*, in our opinion, as scientists do more than the investigative dimension activities. They also perform experiments or measurements, whereby they work with their hands and thereby this could be included in the *Realistic* dimension, for instance. Therefore, Dierks, Höffler & Parchmann (2014) and Wentorf, Höffler & Parchmann (2015) collected many scientific activities and sorted them into the RIASEC dimensions. They found scientific activities for all RIASEC dimensions confirming the diversity of scientific aspects described above in the NOS and NOSI constructs. Furthermore, they identified activities of a seventh dimension *Networking* (N), i.e., exchanging knowledge with peers of different work groups. The resulting RIASEC+N model seems suitable for the diversity of scientific activities. Furthermore, Wentorf, Höffler & Parchmann (2015) used this model to measure self-assessments of students regarding the different scientific activities. Therefore, they developed a questionnaire by considering both students' and scientists' answers about their concept of scientific activities. For the development of the new questionnaire used in the presented project, only scientists were asked as experts to measure an authentic concept regarding scientific activities (Laherto et al., 2018; Stamer et al., 2019). Mixed items of both groups, including students' answers, would not represent an authentic concept of science, which is why the instrument of Wentorf, Höffler, & Parchmann (2015) did not seem suitable and a new questionnaire was developed. Laherto et al. interviews (2018) were used to collect typical scientific activities for the questionnaire. Finally, the activities were sorted into the RIASEC+N dimensions and achieved good to very good interrater agreement ($\kappa = .76$; $\kappa = .96$). The detailed development of the questionnaire is described in Stamer et al. (2019).

Furthermore, as described in the motivation part, stereotypes also exist for further researching fields such as science of history, archaeology or linguistics (Henson, 2012). Therefore it would be interesting to investigate, if the RIASEC+N model can be used in the same way for the other research fields.

3 Project's objectives

The aim of the presented project was to define students' notions regarding scientific activities and to investigate to what extent these conceptions correspond to reality, or rather to the self-perception of scientists about their work. As described in section 2, many typical activities were collected through interviews with scientists during previous examinations. These activities were categorized and finally used to create a questionnaire based on the RIASEC+N model (Wentorf, Höffler & Parchmann, 2015; Stamer et al., 2019).

To assess to what extend the students' conceptions correspond to reality, we compared the students' answers with the answers of the scientists (professors and junior scientists) by using the same instrument. Thus, we aimed to learn which activities are already well known and which have to be promoted (identifying stereotypes).

Consequently, the following research questions were to be investigated:

1. What are the personal views of students regarding typical scientific activities?
2. To what extend do the answers of junior scientists and professors differ?
3. To what extent does students' concept regarding typical scientific activities correspond to the self-perceptions of two groups of scientists: professors and junior scientists?

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Based on studies by Höttecke (2004) and Lederman (2007) we expect that the notions of students regarding the typical work of scientists are insufficient.

4 Instrument and sample

We used a questionnaire containing the following question to answer the research questions: "A scientist is working at a university similar to Kiel University. What do you think this scientist does all day?" We also indicated that scientists include among others biologists, physicists, chemists or material scientists. Overall the questionnaire contains 39 items or rather typical activities of scientists (determined via interviews with professors) which were sorted into the RIASEC+N dimensions. The dimension *Realistic* involves activities such as performing experiments and measurements; *Investigative* includes activities such as interpreting experimental results or reading and writing scientific literature; *Artistic* contains activities such as drafting pictures for scientific articles and testing experiments under various conditions; *Social* involves activities such as supervising university students; *Enterprising* contains activities such as raising funds for research projects; *Conventional* includes activities such as writing down measurement data; *Networking* involves activities such as meeting other scientists at conferences. A related sample item for the dimension Realistic is: "The regular everyday work of a scientist involves performing experiments." To rate the relevance of the different activities we used a four point Likert-scale from strongly disagree (1) to strongly agree (4). Subsequently, 244 students (94 female and 150 male), aged 15-20 years and ranging from grades 10 – 13 answered the questionnaire. The students differed widely regarding grades in school and favourite subjects. We compared the students' answers with those from ten professors and 92 junior scientists in Germany. The chosen scientists are working in different fields such as chemistry, physics, material science and pharmaceutical. A small proportion of the professors who answered the questionnaire were also interviewed regarding designing the questionnaire items. Most of their work and the junior scientists' work is part of the Collaborative Research Centre 677 "Function by switching" (http://www.sfb677.uni-kiel.de), conducted at nine different German research institutes. In addition, 52 junior scientists (a subgroup of the 92 junior scientists) answered the following open question, which was part of the questionnaire: "What aspects should be present in a learning environment to convey an authentic overview of science to students?" Illustrating examples of answers to the question are shown in the discussion section.

5 Results

Apart from the reliabilities of the dimensions *Artistic* and *Networking* which are lower for the student answers, the reliabilities of the RIASEC+N dimensions, shown in Table 2, are between .61 and .90. The presumable cause might be student unawareness regarding some activities of these dimensions.

Table 2. Reliabilities (Cronbach alphas) of the RIASEC+N Dimensions.

Dimension	Items	Stud.	J. Sc.	Prof.
Realistic	6	.61	.73	.83
Investigative	8	.70	.71	-*
Artistic	7	.58	.74	-*

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Social	4	.71	.75	.82
Enterprising	3	.72	.90	.86
Conventional	7	.76	.77	.90
Networking	4	.58	.73	.74

* No calculated reliability because of a missing variance between the answers of the professors

A Levene-test was conducted to examine the variance homogeneity of the RIASEC+N dimensions for the three cohorts. The results in Table 3 show that the variances for some dimensions, unfortunately, are not homogeneous. That is why we chose the Welch-test for calculating the differences between all three groups. The overall differences between students, young researchers and professors are highly significant for all dimensions except the dimension Conventional, as shown in Table 4.

Post-hoc tests (Tamham) were conducted to calculate the significances between two groups. The resulting significance values, the average values and standard deviations are shown in Table 5 and Figure 1. The corresponding effect sizes are shown in Table 6.

For the representation and discussion of the results, the fields of activities will be separated into those dimensions which include mainly stereotypical activities, such as the dimensions *Realistic*, *Investigative* and *Conventional,* and those dimensions which mainly include non-stereotypical activities, such as the dimensions *Artistic*, *Enterprising*, *Social* and *Networking*. In the following, we used the terms stereotypical and non-stereotypical activities for the respective dimensions or rather fields of activities for simplicity reasons.

The results in Figure 1 show that the answers of the professors are significantly higher than the answers of the junior scientists and students, except for the dimensions *Realistic* and *Conventional* which mainly include stereotypical activities. In figures 2 to 4, the RIASEC+N dimensions are sorted into stereotypical and non-stereotypical fields of activities to highlight the differences between these fields. As expected and shown in Table 5 as well as in Figure 2 and 3, the students and junior scientists rated the stereotypical activities of the dimensions *Realistic*, *Conventional* and *Investigative* significantly higher than the non-stereotypical activities (the dimensions *Artistic*, *Social*, *Enterprising* and *Networking*). The professors rated the activities of every dimension high, especially the activities of the dimension Investigative. The activities of the dimension *Realistic* were rated the lowest, as shown in Figure 4.

Table 3. Results of the Levene-test.

Dimension	**Levene-Statistic**	***df*1**	***df*2**	***p***
Realistic	4.252	2	343	.015
Investigative	5.962	2	343	.003
Artistic	1.819	2	343	.165
Social	1.681	2	343	.188
Enterprising	0.969	2	343	.381

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Conventional	3.328	2	343	.037
Networking	7.123	2	343	.001

Table 4. Welch - Test after Variance Analysis.

Dimension	**Statistic**	***df*1**	***df*2**	***p***
Realistic	17.349	2	23.096	<0.001
Investigative	115.362	2	28.859	<0.001
Artistic	64.939	2	24.191	<0.001
Social	30.657	2	24.775	<0.001
Enterprising	53.647	2	23.574	<0.001
Conventional	0.203	2	23.090	0.817
Networking	11.479	2	23.750	<0.001

Table 5. Average Values and Standard Deviations of the Students' (Stud.), Junior Scientists' (J.Sc.) and Professors' (Prof.) Answers.

	M			***SD***		
Dimension	**Stud.**	**J.Sc.**	**Prof.**	**Stud.**	**J.Sc.**	**Prof.**
Realistic	3.00	3.34	2.90	0.42	0.49	0.67
Investigative	3.06	3.52	3.88	0.40	0.33	0.18
Artistic	2.45	2.84	3.63	0.40	0.49	0.37
Social	2.54	2.64	3.65	0.54	0.64	0.43
Enterprising	2.22	1.50	3.50	0.62	0.72	0.72
Conventional	3.32	3.36	3.27	0.42	0.48	0.72
Networking	2.83	2.72	3.50	0.45	0.60	0.47

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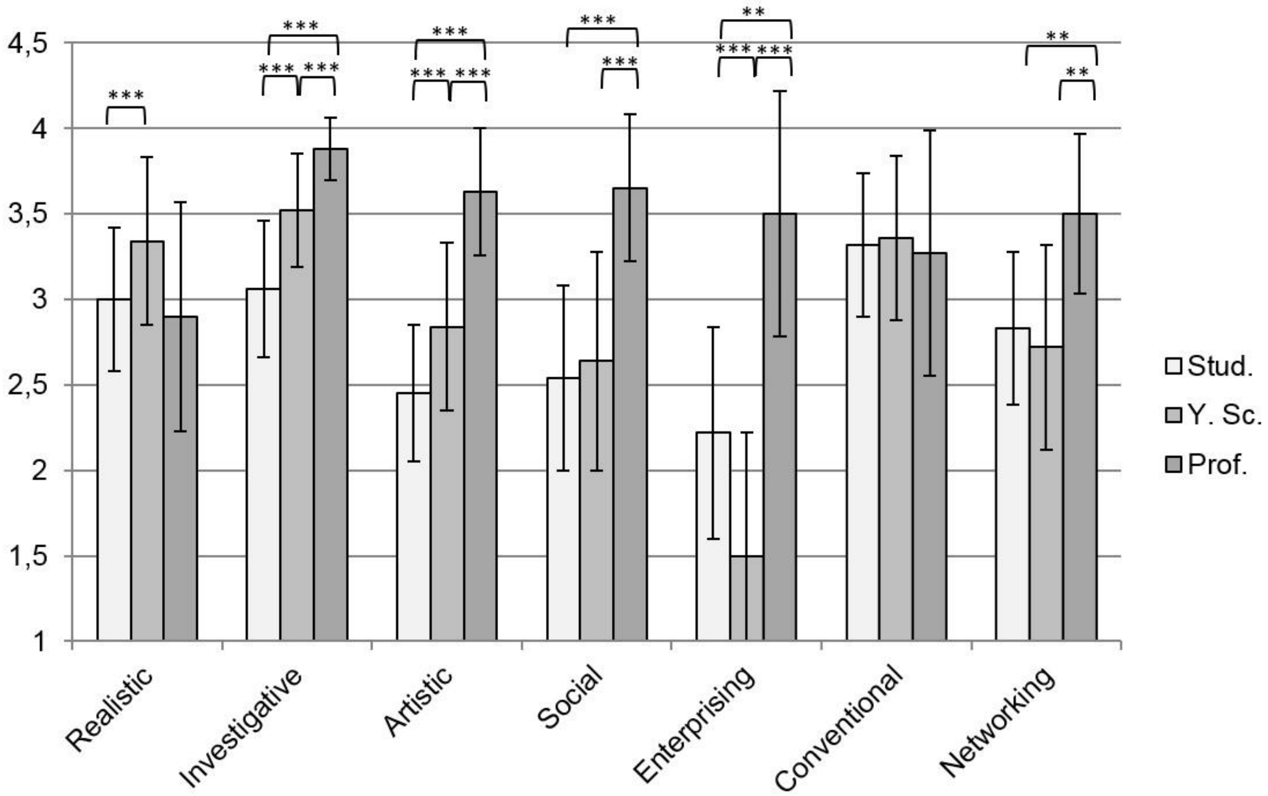

Figure 1. Average values, standard deviations and significances of the students' (in light grey), junior scientists' (in middle grey) and professors' (in dark grey) answers.

Table 6. Effect Sizes (d) Regarding the Differences Between Students', Junior Scientists' and Professors' Answers.

Dimension	*d* Stud./J. Sc.	*d* Stud./Prof.	*d* J. Sc./Prof.
Realistic	0.78	0.23	0.86
Investigative	1.22	2.08	1.13
Artistic	0.92	2.96	1.65
Social	0.17	2.07	1.62
Enterprising	1.11	2.05	2.78
Conventional	0.08	0.11	0.18
Networking	0.23	1.49	1.33

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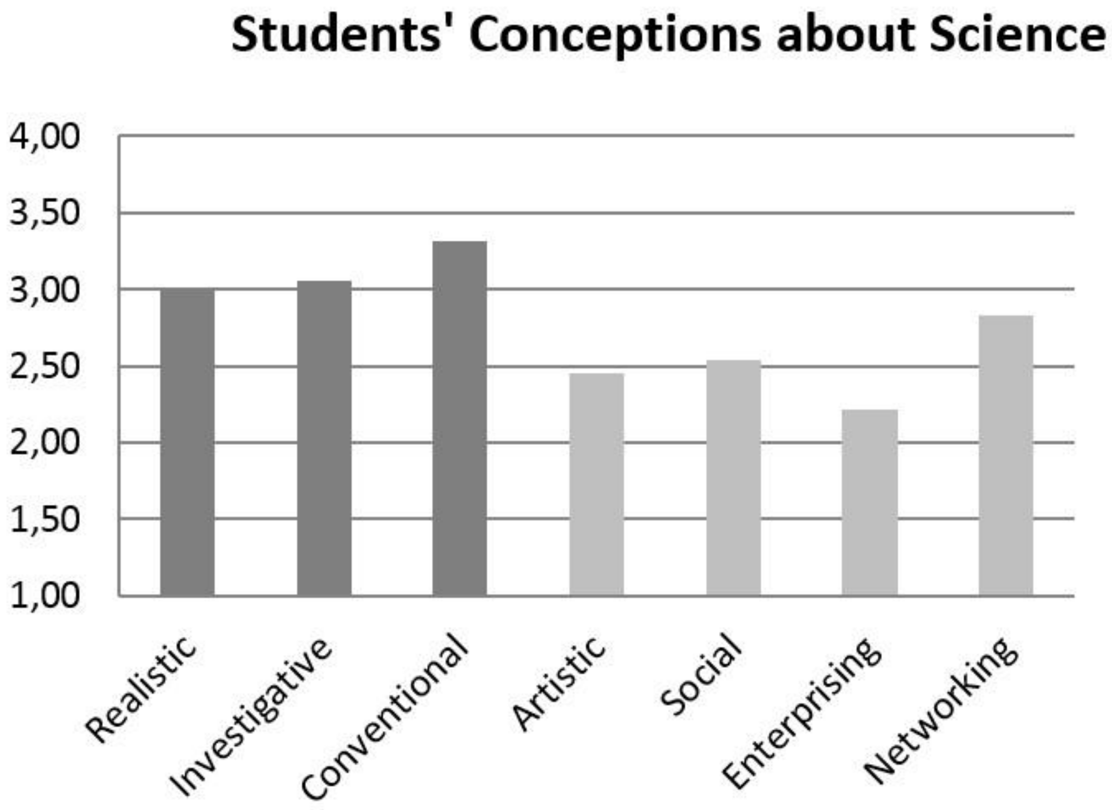

Figure 2. Average values of the student conceptions about science regarding the RIASEC+N dimensions sorted by stereotypical (dark grey) and non-stereotypical dimensions (light grey).

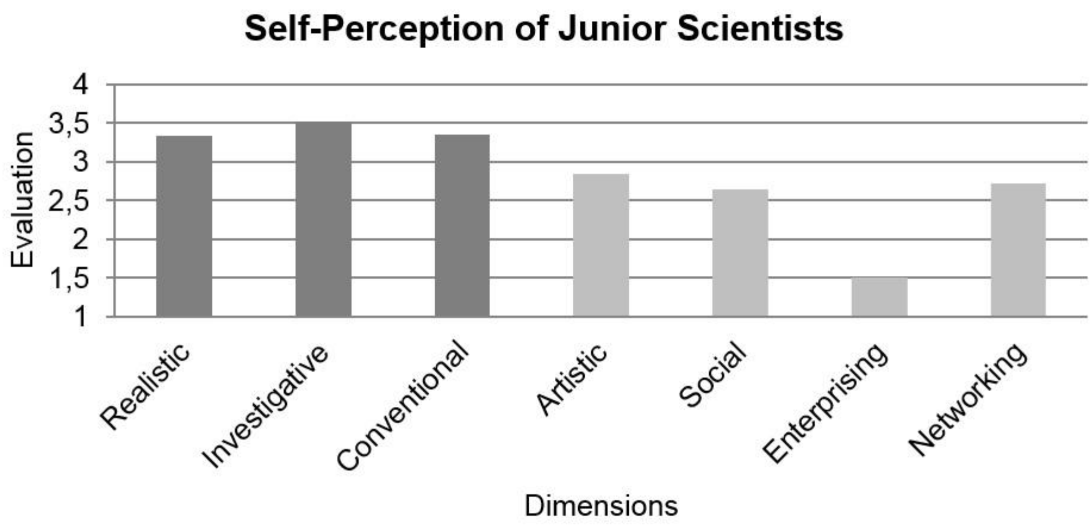

Figure 3. Average values of the self-perception of junior scientists about their own work regarding the RIASEC+N dimensions sorted by stereotypical (dark grey) and non-stereotypical dimensions (light grey).

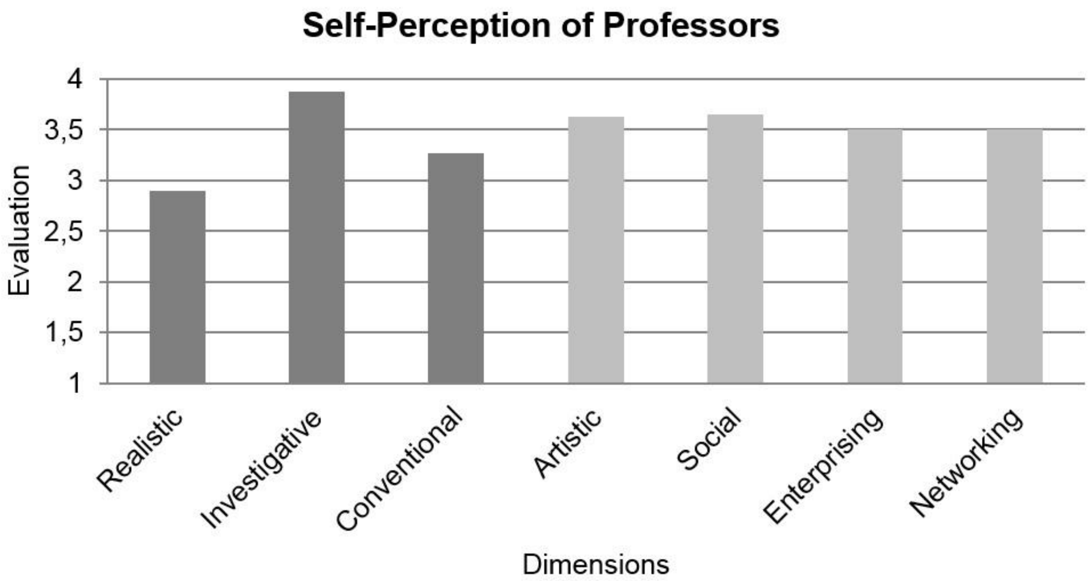

Figure 4. Average values of the self-perception of professors about their own work regarding the RIASEC+N dimensions sorted by stereotypical (dark grey) and non-stereotypical dimensions (light grey).

Table 7. Significance Values (Sig.) Between Stereotypical and Non-Stereotypical Dimensions.

Dimensions	Sig. Stud.	Sig. J. Sc.	Sig. Prof.
Realistic-Artistic	<0.001	<0.001	.010
Realistic-Social	<0.001	<0.001	.002
Realistic-Enterprising	<0.001	<0.001	.080
Realistic-Networking	<0.001	<0.001	.035
Investigative-Artistic	<0.001	<0.001	.039
Investigative-Social	<0.001	<0.001	.029
Investigative-Enterprising	<0.001	<0.001	.077
Investigative-Networking	<0.001	<0.001	.018
Conventional-Artistic	<0.001	<0.001	.218
Conventional-Social	<0.001	<0.001	.047
Conventional-Enterprising	<0.001	<0.001	.491
Conventional-Networking	<0.001	<0.001	.409

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6 Discussion and limitations

In this section we will discuss the results shown in the previous section as well as the limitations of the study. The discussion will be supplemented by quotes of (52) junior scientists (doctoral students and post-doctoral students: a subgroup of the 92 junior scientists that were tested with the questionnaire), who were asked what they would convey to students. More precisely, they were asked the following question:

“What aspects should be present in a learning environment to convey an authentic overview of science to students?”

A closer look at the student answers is helpful to answer the first research question (Figure 1). The results show that the average values of the dimensions which include stereotypical (laboratory) activities such as *conducting experiments or measurements; analysing data; waiting for or repeating measurements* – which belong to the dimensions *Realistic*, *Investigative* and *Conventional* – are rated significantly higher than the non-stereotypical activities as shown in Table 7 and Figure 2. As expected, the students estimate the stereotypical activities as typical for science whereas the other dimensions, especially *Enterprising*, are regarded as less typical for science. Former studies about stereotypical notions of students concerning science can thereby be confirmed. The conceptions found by Solomon, Scott & Duveen (1994) or Sharkawy (2012) for example, contain activities of scientists such as conducting experiments and working alone to obtain new knowledge. The following aspects are not mentioned: Organising funds for projects, working together in interdisciplinary groups and imparting knowledge to students.

Next, the question arises how strongly the students’ conceptions differ from those of the scientists. Here, we compared the students’ answers with those of the junior scientists. All in all, the students’ conceptions do not differ greatly from the self-perception of the junior scientists as the junior scientists also rate the stereotypical activities higher than the non-stereotypical activities (Figure 3). Still, the answers of both groups show significant differences regarding the dimensions R, I, A and E, whereat students underestimate the first three mentioned dimensions.

Correspondingly, a number of the junior scientists emphasized the stereotypical fields when asked what to convey to the students:

> “Expenditure of chemical experiments; analytical evaluation”;

> “Synthesis, documentation, evaluation (…) of results”

These quotes, are examples describing the typical work in a laboratory: Performing experiments (*Realistic*); the repetition and expenditure of experiments and writing down data (*Conventional*); and the interpretation and analysis of data (*Investigative*).

Furthermore, other laboratory relevant aspects such as the equipment and the atmosphere were mentioned:

> "Apparatus, chemicals, especially hazardous substances and safety equipment";

> "Atmosphere in laboratory; safety clothing (lab coat, safety glasses) and conducting experiments"

Non-stereotypical activities were rated lower by the students and junior scientists than the stereotypical activities, but were also mentioned by the scientists as important to convey.

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For example, the quote, "(…) presentation of results", contains the dimension *Networking* or *Social* depending on the audience or the recipient of the presentation. A presentation for students belongs to the dimension *Social* whereas a presentation especially for scientists belongs to the dimension *Networking*. The assertion "(…) developing research questions (…)" belongs to the dimension *Artistic*. Regarding the dimension *Social*, the following was mentioned: "Real research sessions (…)".

In comparing the quotations with the quantitative results of the junior scientists, both underline the importance of the laboratory work and the processing of scientific data regarding the three stereotypical dimensions. The activities of the other dimensions were also mentioned but less frequently, except for the dimension *Enterprising*. Those activities were not mentioned at all in the qualitative study and were also rated lowest in the quantitative results. This can be explained by junior scientists usually not being responsible for the planning of financial resources.

The activities which were descriptively rated as the highest by the students are those of the dimension *Conventional* (with an average value of 3.32); comparing the average values of the student answers with the average values of the scientist answers, *Conventional* is the only dimension without significant differences. It is thereby apparent that students already know these activities.

Regarding all other dimensions, significant differences exist between the conceptions of students and self-perceptions of scientists, especially when considering the answers of the professors.

Before we discuss the differences between the three groups in more detail, we will differentiate between the answers of the junior scientists and professors. Please keep in mind, however, that 92 junior scientists but only 10 professors answered the questionnaire (as there is only a finite number of professors in general). The Welch-test (Table 4) was chosen as an additional statistical method because of the different sample sizes and partially not homogenous variances (Levene-test Table 3). A further limitation is that we cannot know if the assessment of the professors and the junior scientists is of equal importance. For example, the average value of the dimension *Conventional* is similar for both groups with 3.36 and 3.27, but we do not know if the time which both groups spend in these fields is also similar.

Nevertheless, we deem it necessary to differentiate between the answers of the junior scientists and professors, because their daily activities are clearly different. In general, both groups are involved in each area of activities, but with different foci. The junior scientists are more involved in the "stereotypical laboratory work" in contrast to the professors, whose foci of responsibility are the planning of the finances (*Enterprising*) and communicating the research results to other scientists (*Networking*). These different foci of both groups are shown by the average values and significances in Figure 1 and the effect sizes in Table 5. Notable activities include those performed in a laboratory, such as conducting experiments and measurements or waiting for chemical reactions, belonging to the dimensions *Realistic* and *Conventional.* All dimensions, except these two were rated significantly higher by the professors than by the junior scientists. The average value of the dimension *Realistic* is descriptively but not significantly higher for the answers of junior scientists than the answers of the professors.

As mentioned above, the answers of the junior scientists and professors vary widely, but both groups rated the activities of the dimension *Investigative* as highest – or rather, they have the opinion that they are most involved in these activities. This underlines the categorisation of

Holland (1997), who sorted the working field of scientists into the dimension *Investigative*, because they are working mainly with their mind.

In the following, the different foci of the junior scientists and the professors need to be considered when comparing the self-perception of scientists regarding their work with the students' conceptions of scientific activities.

At this point it should be mentioned that we do not know if the students are thinking of junior scientists or professors when answering the questionnaire and if they could differentiate between both groups of scientists. Furthermore we cannot be sure if the scientists are only describing their own work or also the work of their colleagues, supervisors or subordinates (even though clear instructions were given).

These limitations are important and should be kept in mind in the following discussion.

Despite the major differences between the answers of the two groups of scientists, neither perspective is wrong. However, it is important to learn whether the students already know about the diversity of scientific work. We do not aim to match student answers exactly to the self-perceptions of the professors or junior scientists. It is more important by far that the students know about the diversity of the work of scientists, so that all different fields of activities are well-known versus only the stereotypical activities. This diversity has been shown to be extremely important: Hollander & Parker (1972) and Hannover & Kessels (2002) showed the important role of stereotypes regarding occupational choices.

Therefore we considered the student answers regarding the seven scientific RIASEC+N working fields and compared them to the answers of the two groups of scientists (second research question). Regarding the dimension *Conventional*, there is no significant difference between students' and scientists' perceptions. The average values of the students and scientists answers are similar as shown in Figure 1 and Table 4; hence, the students already know these activities. The activities of the dimensions *Realistic* and *Networking* are also well-known, but in these cases the answers of the groups of scientists differ so that the student answers are rated between the answers of the junior scientists and professors. The activities of the dimensions *Investigative*, *Artistic* and *Social* are being underestimated and should be promoted even if the activities of the dimension *Investigative* are rated highly with a mean of 3.06 (3 = "agree somewhat"). The activities of the dimension *Enterprising* are not typical for the junior scientists and they ranked them between *strongly disagree* and *disagree somewhat* (with $M = 1.50$). In contrast, these activities are much more typical for professors, who ranked them between *agree somewhat* and *strongly agree* ($M = 3.50$). The students' answers are in between with $M = 2.22$. Thus, as mentioned above, they ranked the dimension *Enterprising* as lowest. This average value means that the students disagree more than they agree that these activities are scientific activities. However, these activities play an important role in scientists' finances as shown by the answers of the professors.

7 Conclusion and outlook

The results of the personal views of students regarding typical scientific activities show that students associate stereotypical activities much more with scientific work than with non-stereotypical activities. Thus, the stereotypical conceptions about scientists described in the literature are confirmed (Höttecke, 2004; Solomon, Scott & Duveen, 1994, Sharkawy, 2012; Höttecke & Hopf, 2018; Tintori & Palomba, 2017).

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By comparing the students' answers with the answers of the junior scientists and professors, it should be emphasised that the aim is not to adjust the students' answers to the answers of junior scientists or professors. The students should not rate the activities of the dimension *Enterprising* as low as the junior scientists, for example, and they also should not rate the stereotypical activities lower than the non-stereotypical activities, as the professors do.

Rather, the aim should be students knowing about all the different working areas of scientists, so that they have an authentic overview what it means to be a scientist and they can make a well-informed vocational decision.

The results of this study show that students already know about many scientific activities, especially the stereotypical activities. This corresponds with previous findings in the literature. The answers of the scientists underline that these activities are still important and that they play a key role in science, especially for the junior scientists. There are also other less known non-stereotypical activities, especially those of the dimensions *Enterprising*, *Artistic* and *Social*. These activities are more typical for professors than for the junior scientists, but they are nevertheless important. Thus, knowledge about them should be promoted.

These findings are of great importance in general because they can be used as a basis for interventions to promote an authentic image of science. For example, these aspects can be integrated into out-of-school or in school education. One possibility is students working as scientists on tasks including these aspects. Another option was mentioned by a junior scientist, who answered the question, "What aspects should be presented in a learning environment for students to convey an authentic overview of science?":

> "The opportunity to interact with professors would make it authentic"

While this certainly makes sense, professors unfortunately often lack time for such activities. Thus, an alternative might include other methods, for example, videos including these scientific aspects featuring real scientists (Authors, accepted). Furthermore, it would be interesting to investigate the effects of such authentic insights on interest in science and motivation to do scientific activities.

Finally, comparable investigations such as the current one would be interesting for other researching or occupational fields, as these also have stereotypical conceptions. For example, the high ratings of the professors regarding the non-stereotypical dimensions, such as *Enterprising,* are probably not only of high importance to scientific professors but also for professors of other disciplines, which is why the questionnaire should also be used for further disciplines.

It is relevant especially for young people, to know about the diversity of possible occupations before they make vocational decisions.

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