Systemising and empathising in early years science – a video-based study with pre-school children

● Nina Skorsetz ● Manuela Welzel-Breuer

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Abstract

Children are very different in their motivation to do science. An approach used to explain these differences in the motivation for science could be through the Empathizing-Systemizing (E-S)-Theory (Baron-Cohen, 2009). This theory states that every person's brain has two dimensions: the systemising and the empathising. Both dimensions can be measured with a questionnaire and represented in an EQ- and a SQ-value.

People with a high SQ-value are called 'systemisers' and tend to search for systems behind things; 'empathisers' orientate themselves to other people's feelings. Systemisers are generally more engaged in science and more motivated to do science than people with a high EQ-value, who are stronger in empathising (Zeyer et al, 2013).

The main goal of this study is to find out if pre-school children with various EQ- and SQ-values act differently in different scientific learning environments. Children were observed during two pedagogically differently arranged learning environments, to investigate potential different behaviour. In this study, the brain types with respect to the EQ- and SQ-values of 4 to 6 year-old pre-school children were determined with a 55-item EQ-SQ questionnaire (Auyeung et al, 2009), which was translated into German. In terms of a design-based research approach (Collective, 2003), the tested children were video-observed while participating in the two different scientific learning environments, in spring 2015 and 2016.

Results seem to show that children with a high SQ-value, as reported in literature, tend to be more motivated to do science than children with a high EQ-value. Children with a high SQ-value were motivated in both learning environments, which could lead to the interpretation that these children are motivated to do science independent from the pedagogical arrangement of the learning environment. For children with a high EQ-value, no such correlations for their motivation to do science were found. They seem to be less motivated in both learning environments than children with high SQ-value. More research is needed.

Keywords: Early years science, video-based research, design-based research

Introduction

Starting point: Diversity

Children in kindergarten are often very motivated to do science, but this motivation varies from child to child and fades away with age (Patrick & Mantzicopoulos, 2015). One usual explanation for the different motivation to do science is the gender difference between boys and girls. A slightly different approach for explaining differences in the motivation for science is the *Empathizing-Systemizing (E-S)-Theory* by Baron-Cohen (2002). The basis of his theory is that every human brain has two dimensions. On the one hand, there is the 'empathising' dimension, which is defined by the drive to *'identify another's mental states and to respond to these with an appropriate emotion, in order to predict and to respond to the behaviour of another person'* (Baron-Cohen *et al*, 2005). On the other hand, there is the 'systemising' dimension,

which is defined as *'the drive to analyze or construct systems'* (Baron-Cohen, 2009, p.71). With questionnaires, the measure of the peculiarity of both dimensions – called EQ and SQ – can be determined (Billington *et al,* 2007).

People with a high SQ-value, called 'systemisers', are generally more engaged in science than people who are stronger in empathising (Zeyer *et al,* 2013, p.1047). In Baron-Cohen's studies, it seems that the two dimensions are independent from each other. Baron-Cohen and his colleagues calculated the difference between the EQ- and SQ-value and statistically identified five so-called brain types: *Extreme Empathisers; Empathisers; Balanced; Systemisers;* and *Extreme Systemisers.* Further studies showed that the two dimensions do not depend on each other and the concept of brain types was sometimes misleading, because a person can have a balanced brain type, with either two similarly high EQ- and SQ-values or two similar minor values (Svedholm-Häkkinen & Lindeman, 2015, p.366).

Zeyer *et al* (2013) showed that only the SQ-value has an impact on the motivation to do science. So far, the relation between the SQ-value and motivation for science has not been tested with young children, only with high school students. However, the EQ- and SQ-values can be measured for 4-11 year-old children using a combined 55-item EQ-SQ Child Questionnaire, which was validated in a large study with over 1500 participants (Auyeung *et al,* 2009). In this case, the parents filled out the questionnaire for their children.

In this current study, the goal is to find out whether there are differences in motivation between systemisers and empathisers when attending scientific learning environments at kindergarten (Skorsetz & Welzel, 2015). Maybe children with different brain types need different forms of access to science (Zeyer *et al,* 2013, p.1047)?

What is motivation?

Before we can find out how motivated pre-school children are when participating in scientific learning environments, we have to first define the term 'motivation'. A useful definition is: *'Motivation is an internal condition that elicits, leads and maintains the children's behaviour'* (Glynn & Koballa, 2006).

'Motivation' is here being considered to be motivation to learn something, or the desire to gather knowledge (Artelt, 2005). Motivation can be seen as 'time on task' (Artelt, 2005, p.233) spent focusing on the subject. If somebody is motivated to learn something, s/he will probably spend more time on it.

There are several constructs concerning motivation. Following Glynn & Koballa (2006), these are, for instance, intrinsic/extrinsic motivation, goal orientation, self-confidence, self-determination and anxiety (Glynn & Koballa, 2006). Thus, the challenge is to observe different aspects of motivation, knowing that *'motivation cannot be observed directly'* (Barth, 2010). Different types of instruments measure the amount of motivation, such as the Leuven's scale of involvement/engagement (Laevers, 2007). Within this measure, Laevers specified different signs of motivation: bodily posture, attentiveness, endurance, accuracy, responsiveness and contentment. If we assume that someone is motivated when s/he follows attentively in a situation, we can observe the different focus of attention that the children choose in the scientific learning situations, and their duration.

Early years science in German kindergartens

In German kindergartens it is common practice to use two different approaches to do science. The main difference between these two approaches is in the degree of structuring of the didactical and methodic arrangements used. An aspect that both ways have in common is that the learning environment often starts with the exploration of a natural phenomenon.

The first applied approach is 'rather structured', because the idea is that the child co-constructs new knowledge with others: for example, in a structured experiment an instruction is followed by an interpretation and guided by questions and interventions of the teacher (Lück, 2009). In this way, the learning environment is led and structured by the pre-school teacher. The pre-school teacher and the children are often sitting around a table. The materials to be used are displayed by the teacher on a dark pad and labelled by both teacher and children. A manual is used, which is followed using a step-by-step procedure.

The experimentation phase is followed by an interpretation phase, where the children try to find an explanation for the phenomenon.

For the other approach, the idea is that the child makes holistic (nature) experiences together with others, in a playful way and in a communicative setting. Hence, s/he has the possibility to identify him/herself with somebody else, or with a situation in a social setting, for example through a fictional framing story (Schäfer, 2008, 2015). The children and the teacher are often sitting on the floor in a circle and the materials are displayed. A framing story is 'told' by a puppet, for example, and the story ends with a problem encountered by the puppet, which has to be solved by the children. After the story, the children have time to explore the materials or the phenomenon and solve the problem in their own way, in order to 'help' the puppet.

Research questions

The main goal of this study is to find out how pre-school children with different EQ-/SQ-values act and react in different didactical and methodical learning environments, on the same scientific topic. In other words, we are observing children in the two different learning environments in order to investigate potential different behaviour.

Our hypotheses in this context are:

- H1: Systemisers could be more motivated to do science in more structured learning environments because of their higher SQ-value, which leads them to search for systems.
- H2: According to Zeyer *et al* (2013), we assume that fictional stories and the possible identification with protagonists should especially motivate empathisers to do science. An additional idea is that learning environments that include time to explore the materials could be motivating for empathisers.

Based on these hypotheses, we developed the following research questions in order to find differences between the children in two contrasting learning environments. First, we have to find out whether different EQ- and SQ-values can be found among pre-school children:

- RQ1: *To what extent do pre-school children show empathising or systemising characteristics?*

At first, all tested children in the first year of the project and of both brain types participated in a more structured setting. In the following year, other tested children (the 'next generation'), again of both brain types, participated in the more exploratory learning environment. So, our research question is specified for the two settings:

- RQ2: *To what extent is the influence of brain type or of the EQ- and SQ-value reflected in differences in children's actions in a 'rather structured' (RQ 2.1), or a 'rather open' (RQ 2.2), learning environment based on the behaviour chosen for measurement and its duration?*

Method

In order to answer the research questions, our study was organised in three steps:

- (1): implementation of the EQ-SQ Child Questionnaire (developed by Auyeung *et al*, 2009);
- (2): implementation of the more structured learning setting, and of the rather exploratory type of learning environment; and
- (3): analysis of correlations between the brain type of the children and their actions in the different learning settings.

(1): At first we had to translate and validate the EQ-SQ Child Questionnaire (Auyeung *et al*, 2009) in order to determine the EQ- and SQ-values of every child in a communicative validation process (Lamnek *et al*, 2010). The questionnaire was given to the children's parents because of the young age of the children participating in the study. The tested children were 5-6 years old and were in the last year of kindergarten before entering primary school.

(2): In order to measure different actions concerning the children's motivation and to investigate if these were independent of the didactical and methodological arrangement of the learning environment, a two-step procedure was followed, where children participated in one of the

two contrasting scientific learning environments. Both learning environments were based on the same scientific phenomenon: 'absorbency properties of different materials' (Krahn, 2005). The learning environments were theory-based and evaluated using the Design Based Research approach (DBR Collective, 2007).

One of the mixed groups of tested children participated in the 'rather structured' approach; the other group participated in the 'rather open' approach. The children's behaviour (n=50) was observed (video-recorded) carefully. The same procedure was performed with the 'rather open' approach in the following year. The videotapes formed the basis for the empirical analysis, using inductively developed observational categories focusing on what the children were looking at (Mayring, 2008).

(3): The third and last step was to calculate statistically the correlation between the compiled EQ- response and SQ-values with the data from the video analysis, in order to find the expected significant differences between the two groups of children (Bortz & Döring, 2006).

Results

The EQ-SQ Questionnaire

The analysis of the questionnaire was carried out with the participation of different researchers from different faculties in order to achieve communicative validation (Lamnek *et al,* 2010). About 17 scientists, who usually meet regularly during a seminar, participated in this two-step procedure. For the pre-test, the first version of the questionnaire in German was trialled with a mother and her child in that age group. From this, we obtained answers to the questions, as well as comments about the clarity of the questions. After another communicative validation process with the above research group, based on the mother's comments, the second and improved version of the questionnaire was finalised. The pilot study followed, with the questionnaire administered to 25 parents of pre-school children. The internal consistency of the results was tested statistically. Cronbach's alpha coefficients were calculated and showed acceptable coefficients for empathy items (α=0.81), as well as for systemising items (α=0.61). This result is in accordance with the literature (Auyeung *et al*, 2009). Thus, we can conclude that the translated questionnaire was valid and reliable. Overall, 112 children were tested by the questionnaire during data collection in the spring of 2015 and spring 2016.

Development, implementation and analysis of the learning environment

Both learning environments were based on the scientific phenomenon of absorbency. We expected the children to recognise this phenomenon from situations experienced at home and in kindergarten and involving the spilling of fluids.

For the study, children with brain type/EQ- and SQ-value participated in the learning environment in groups of four. All activities were video-recorded using two video cameras filming the sequences from different angles. During the summers of 2015 and 2016, 99 pre-school children, aged 5-6, from seven different kindergartens in the area of Heidelberg, Germany, were filmed.

The data collection of the 'rather structured' learning environment took place in spring/summer 2015 in 15 settings with 52 children. The data collection of the 'rather exploratory' learning environment comprised of 14 settings with 47 children, which was implemented in spring/summer 2016. Hence, the total number of video material added up to about 10 hours.

The two videotapes of each setting were inputted in the evaluation software programme *Videograph* (Rimmele, 2012) and synchronised. Inductively, we developed eight observation categories with the focus on the children's viewing directions. These included children looking:

- Towards the pre-school teacher
- Towards other children
- At the experimentation material
- Towards the observer/into the camera
- Around
- At material not relevant to the immediate situation
- Indistinguishable
- At anything else

Variable	2	3	4	5	6	7	8	9	10
1 Difference	– .69**	– .38**	– .03	– .16	.16	–.01	–.10	–.18	–.14
2 EQ		–.32**	.12	–.22	–.11	–.09	–.06	–.09	–.08
3 SQ			–.21	.04	.00	–.07	–.02	–.31*	–.28*

Notes: Difference = Difference EQ/SQ = Brain Type, EQ = relative EQ-value (2); SQ = relative SQ-value (3), Teacher = View towards Preschool Teacher (4), Children = View towards other Children (5), Exp.mat. = View towards the Experimentation Material (6), Cam. = View toward the Observer/into the Camera (7), Around = View around (8), Mat. n. r. = View t. Material that is not relevant right now (9), Distraction (10)
* p < .05, ** p < .01. (one-tailed)

Table 1: Correlations ('rather structured' learning environment).

Next, we converged categories 4, 5 and 6 into a new category, 'Distraction/ Attentiveness'. The 6th category involved material that the children stored in their pockets, or experimentation material that had been used before but was no longer relevant. The 8th category was not used. A manual was produced.

The videotapes of both learning environments were then analysed in detail according to the manual. All videos were analysed by two coders. In the 'rather structured' learning environment, the children's viewing directions were gathered for the whole setting. With the software programme *Videograph*, the duration was measured as a percentage independent from the duration of the setting. Different codes were identified and discussed in the communicative validation process (Lamnek *et al,* 2010). The same procedure was followed with the 'rather exploratory' learning environment. In contrast to the first setting, the coding of the viewing directions of the children started just after the end of the presentation of the framing story.

Correlations

In order to answer the second research question, the EQ- and SQ-values of each child were correlated using the video-analysed data. Table 1 shows the results of the correlations of the data from the 'rather structured' learning environment and the children's EQ- and SQ-value. Two significant values were identified in this one-tailed Spearman correlation: r=–.31* (negative correlation between SQ and 'View to material that is not relevant right now', row 3, column 9) and r=–.28* (negative correlation between SQ and

Variable	2	3	4	5	6	7	8	9	10	11
1 Difference	–.68**	.56**	–.02	.04	.02	–.03	.01	**.34****	–.14	–.02
2 EQ		.20	–.05	.17	.11	–.02	–.14	**.28***	–.08	–.14
3 SQ			.04	.20	.11	–.01	–.12	–.23	.13	–.16

Notes: Difference = Difference EQ/SQ = Brain Type, EQ = relative EQ-value (2); SQ = relative SQ-value (3), Teacher = View towards Preschool Teacher (4), Children = View towards other Children (5), Exp.mat. = View towards the Experimentation Material (6), Cam. = View toward the Observer/into the Camera (7), Around = View around (8), Mat. n. r. = View t. Material that is not relevant right now (9), Puppet = View towards Hand-puppet (10), Distraction (11)

Table 2: Correlations ('rather open' learning environment).

'Distraction', row 3, column 10). This means that children with a higher SQ-value tend to be more focused on the scientific related aspects.

In Table 2, the results of the correlation in the 'rather exploratory' learning environment with the children's EQ- and SQ-values are displayed. Our study has relevant correlation with a significant value (r=.28*, row 2, column 9) between the EQ-value and the 'view towards material that is not relevant right now'.

This means that children with a higher EQ-value tend to focus on non-relevant aspects, so they seem to be more distracted than children with a higher SQ-value. Another significant value is r=–.34** (variable difference, row 1, column 9) between the children's brain type and the 'view towards material that is not relevant right now'. This result could be interpreted as children with a higher SQ-value (in the difference accumulated) focusing less on distracting material. This could also be interpreted as meaning that, again, children with a high SQ-value are more motivated to do science.

Limitations

Looking critically at the data, we have to take into account specific limitations. Firstly, the parents filled in the EQ/SQ Child Questionnaire and evaluated their own children. Some of their answers could be socially desirable.

Secondly, characteristics (perhaps relevant) other than the EQ- and SQ-values were not collected through the questionnaire (e.g. socio-economical background, intelligence, previous knowledge), and no longitudinal data of the children were available. Thirdly, the influence of the use of small groups when the children participated in the learning environments could not be investigated.

Additionally, only some selected aspects, such as the focus of the children's views, which were considered as measures for motivation based on their duration, were observed in this study.

Finally, the comparability of the groups in the sample of 2015 and 2016 might not be entirely accurate given the random composition of pre-school children.

Discussion and conclusions

The first conclusion that we drew from the results was that children with a high SQ-value seem to be motivated in both learning environments. So, children with a high SQ-value seem to be motivated to do science independent of the learning environment and the pedagogical approach used. This result matches our first hypothesis with respect to children with a high SQ-value being motivated to do science in structured learning environments. The results go beyond this hypothesis, because the children always seem to be motivated to do science whatever the learning environment.
However, the second hypothesis can neither be confirmed nor refuted, because we found no hint that children with a high EQ-value seem to be motivated to do science in the different learning environments. Maybe these children prefer to focus on the non-relevant material to contribute to the learning environment.

Therefore, the significant correlations lead to the following hypotheses, which need to be investigated further:

- Children with high SQ-values tend to be motivated to do science independent from the learning environment; and
- The 'rather open' learning environment motivates children with high EQ-values due to the possibility of choosing additional material for their activities.

Further analyses of the quantity and choice of objects touched and labelled could be an interesting additional focus.

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Nina Skorsetz and **Manuela Welzel-Breuer,**
Goethe University Frankfurt/Main and University of Education, Heidelberg, Germany.
E-mails: skorsetz@em.uni-frankfurt.de and welzel@ph-heidelberg.