# SYSTEMIZING AND EMPATHIZING: RESEARCH ON EARLY YEARS SCIENCE EDUCATION AND BRAIN TYPES

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*Abstract:* Main goal of the study is to find out how pre-school children act and react in different learning environments. An approach for explaining differences in the motivation for science is the Empathizing-Systemizing (E-S)-Theory (Baron-Cohen, 2002). It says that every person has a so called "brain type". People who have the brain type "systemizer" are generally more engaged in science and motivated to do science than people who are stronger in empathizing (Zeyer et al., 2013).

Tested children will be observed within two different, according to the brain type characteristics designed, learning environments to investigate potential different behavior. Thus, our main research question is: What kind of attentiveness related reactions do tested empathizing and systemizing preschool children show towards a specific "systemizing" and a specific "empathizing" approach?

In this study the brain types of 4 to 6 year old pre-school children were determined with a 55 item EQ-SQ-questionnaire (Auyeung et al., 2009) that we translated into German. In terms of a design-based research approach (Collective, 2003) the tested children will be observed while acting within two different scientific learning environments.

Until June 2015 the parents of 25 children filled out the EQ-SQ-Questionnaire und the children were videotaped while acting in a systematic scientific learning environment. For the questionnaire, Cronbach's alpha coefficients were calculated und showed high coefficients for empathy items ($\alpha$=0.81) as well as for systemizing items ($\alpha$=0.61). Within this small population a normal distribution can be shown (as Auyeung et al., 2009): 1 EE, 8 E, 7 B, 8 S and 1 ES. We analyzed the videotapes using a category based system with focus on the children's perspective and discovered that so far the children with the same brain type shows various periods of attentiveness but not significant variant between the different brain types.

*Keywords:* early years science, video based research, design based research

## INTRODUCTION

### Science for all

An interesting approach for explaining differences in the motivation for science is the Empathizing-Systemizing (E-S)-Theory (Baron-Cohen, 2002). It says that every person has a so called "brain type". People who have the brain type "systemizer" are generally more engaged in science than people who are stronger in empathizing. Focusing the problem that "science for all" (Aikenhead, 2001, p. 3) is wanted (in order to overcome the lack of people who are interested in studying and doing science) and not a "swing away from science" (Zeyer et. al., 2013, p. 1047), what often is observed, we have to motivate also empathizers for science. But, the problem to be solved is how to realize that.

According to the E-S-Theory, individual's brains should correlate to a type between two dimensions: the empathizing and the systemizing. "Systemizing is the drive to analyze or construct systems" (Baron-Cohen, 2009, p. 71). The goal of this dimension is "to identify

rules that determine a system" (Zeyer et al., 2013, p. 1048) and to "predict how that system will behave" (Baron-Cohen, 2009, p. 71). "Empathizing is the drive to identify another person‘s emotions and thoughts and to respond to these with an appropriate emotion" (Auyeung et al., 2009). In the majority of cases people shift between the two dimensions (Baron-Cohen, 2009, p. 72).

With a questionnaire the measure of the peculiarity of these dimensions – called EQ and SQ – can be determined. Baron-Cohen (2009) identified five different brain types: Extreme E, E, Balanced, S und Extreme S. Billington et al. (2007) found that the brain type seems to be a better predictor than gender, concerning the individual motivation to study science. Through an empirical cross-cultural study Zeyer et al. (2013) added the finding that only systemizing has an impact on motivation to study science. The questionnaire used here (and which can be found in the section "Appendix") was adapted and validated for 4 to 11 year old children by Auyeung et al. (2009). Just like adults, children could be allocated to brain types. From that, Zeyer et al. (2012) concluded that people with an empathizing or a systemizing cognitive style need different approaches to science because, due to their brain types, they are not similarly motivated in this field of education. In order to motivate empathizing children for science they suggest to reorganize the lessons or the learning environments. They recommend first-person-perspectives and context-based-approaches, i.e. approaches with an individual relatedness. Topics that include these aspects could be e.g. health and environment. Furthermore, the teaching should be attached didactically-methodologically, such as field trips, collaborative projects and fostering autonomy (Zeyer et al., 2013, p. 1062).

## Early Years Science and Motivation

In German kindergarten the pre-school teachers often prepare learning environments which are oriented at their own experience with science lessons. These are approaches are more or less structured in their procedure and content.

Within this study, it will be investigated whether there are differences in the motivation of pre-school children with respect to the degree of the structuring in scientific learning environments. We pursue the question, whether tested empathizing children can be motivated to do science if it is prepared in different ways for them.

At the common practice, different approaches to science for kindergartens are existing. Seeing the child as "protagonist of its own development", while adopting its knowledge like a scientist by "being self-actuating", is one of the approaches (Schäfer, 2011, p. 27). Fthenakis (2009) sees the child as an active part of its own educational process in co-construction with others. Lück (2003) proposes children to construct their new knowledge – e.g. in a pre-structured series of experiments and a subsequent interpretation. Finally, we assume that fictions and the identification with protagonists should better motivate empathizers to do science. These different approaches will guide us for the design of two different types of learning environments with respect to the needs of the different brain types.

Main goal of this study is to find out how motivated pre-school children with different brain types appear within different learning environments. Tested (to their brain type) children will be observed within two different, according to the brain type characteristics designed, learning environments in order to investigate potential different behavior.

Knowing that motivation is an internal condition that elicits, leads and maintains the children's behavior (Glynn & Koballa, 2006, p. 25) we have to find observable behavior because we also know that "motivation cannot be observed directly" (Barth, 2010). Laevers (2007) identified in the "Leuven Scale of Active Engagement in Learning" different signs of motivation. These are bodily posture, attentiveness, endurance, accuracy, responsiveness and contentment (Laevers, 2007). In the first step we will focus on the attentiveness.

Our research questions are:

What kind of attentiveness related reactions do tested empathizing and systemizing pre-school children show towards a rather specific “systemizing” and a specific “empathizing” approach?

At first the children participate the more structured setting. So our specific research question is: Do the empathizing and systemizing children show different behavior concerning their attentiveness in a more systematic learning environment?

One possible empirically observable behavior is the period of time that children are attentive in a learning environment. Hüther (2010) argues: “Attentiveness is the door for learning. Who wants to learn, has to focus his attention, therefor to reduce the importance of other stimuli such as his neighbor, the mobile phone, the teacher’s earring, the passing bus etc. Only the learner decides to be concentrated” (Hüther, 2010; cited in Richter, 2015).

If we assume that someone is motivated when he or she follows attentively in a situation, the children’s attention should be shortened in learning environments that are not according to their brain type.

# METHOD

Based on the E-S-Theory we developed a rather “systemizing” and a rather “empathizing” learning environment on the same topic for kindergarten children. We translated the EQ-SQ-Child questionnaire into German and will apply it to about 100 pre-school children.

In terms of a design-based research approach (Collective, 2003), one part of the mixed groups will participate in the “systemizing” approach; the other part will participate in the “empathizing” approach. The children’s behavior will be observed (video-recording) carefully. First, we will film 50 tested pre-school children. The same procedure will be performed with the “empathizing” approach in year two of the project.

The videotapes will be the basis for an empirical analysis (Mayring, 2008). We will start by putting the focus on the children’s attention. At first, we inductively developed categories with the focus on the children’s viewing direction. A more qualitative analysis should follow.

# RESULTS

## The EQ-SQ-Questionnaire

By now, the first 25 children of the population have been investigated. The internal consistency of the results has been tested. Cronbach’s alpha coefficients were calculated und showed high coefficients for empathy items ($\alpha$=0.81) as well as for systemizing items ($\alpha$=0.61). Within this group we found a normal distribution: 1 EE, 8 E, 7 B, 8 S and 1 ES. This result is in accordance to the literature data of Auyeung et al. (2009). Thus, we can conclude that the translated questionnaire should be valid and reliable.

The results show – in comparison with the distribution of values in the original study – that as presented in Figure 1 the extreme values (EE=Extreme Empathizer und ES=Extreme Systemizer) were not acquired in our Pilot Study I.

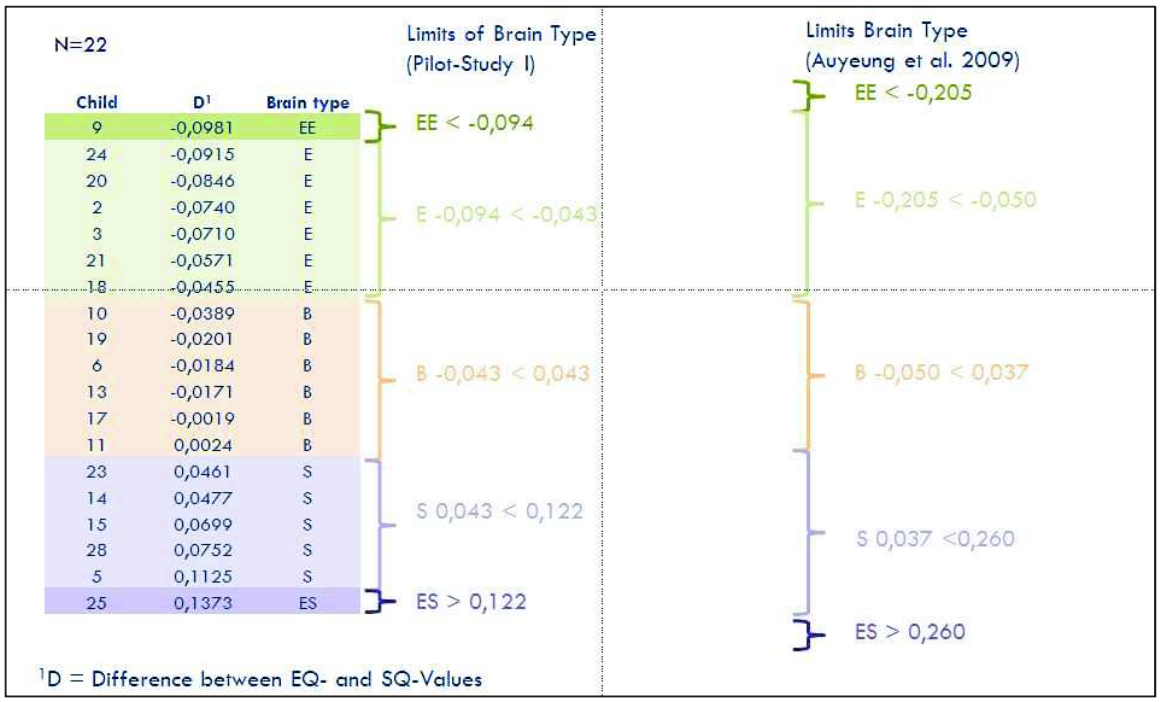


**Figure 1. Classification of Brain Type in Pilot Study I**

## Development of Learning Environment

For the first setting – the rather systematic one – we screened the literature and singled out described systemizing characteristics. We chose an experiment which was delineated by Lück (2007) and titled as "What is absorbent?" Thereby, the children follow a sketched manual and compare the different absorbing traits of super-absorber crystals in diapers with cotton wool and aluminum foil.

The selected learning environment represents a lot of described systemizing characteristics such as dealing with manuals and sorting of things (here: to line up the three materials in order of their degree of absorbency). We found a student who already had a pre-school teacher education to perform the setting.

To ensure the setting will proceed as similar as possible we compiled a so called "script" with determined activity instruction and talk. After a pretest in one kindergarten the script was revised.

For the study, children with tested brain type participated the learning environment in groups of four. During their activities, they were videotaped using two camcorders from different perspectives. Until now, the systematic setting was implemented with 22 pre-school children from age 5 to 6 in three different kindergartens in the area Heidelberg.

## Data Analysis

The two videotapes of each setting were inset in the evaluation software program "Videograph" (Rimmele, 2012) und synchronized. Inductively we developed eight observation categories with the focus on the children's viewing directions:

1. Towards Preschool Teacher
2. Towards other Children

3. At the Experimentation Material
4. Towards the Observer/into the Camera
5. Around
6. Material, that is not relevant right now
7. Indistinguishable
8. Any other business

In the following step we summarized the fourth, fifth and sixth code to a new category "Distraction/Attentiveness".

After the evaluation of the videotapes focusing the children's viewing directions, we compared the two children with the extreme brain types (child 9= EE and child 25=ES). Looking at the direct relation (shown in Table 1) it was seen that there are differences in the duration time of viewing in different directions. The extreme empathizing child looks 8,18 % at other children. On the contrary, the extreme systemizing child looks at this direction only 4,29 % of the whole time. Also the new code "Distraction/Attentiveness" displays a difference in the viewing time (child 9=12,16% and child 25=7,99%). The empathizing child seems to be longer distracted than the systemizing child. These results match our hypothesis.

| Child | Brain type | Towards Preschool Teacher | Towards other children | At the Experimentation Material | Towards Observer/ camera | Around | Material that is not relevant right now | Indistinguishable | Any other business | Distraction Attentiveness |
|---|---|---|---|---|---|---|---|---|---|---|
| S-9 | EE | 14,84% | 8,18% | 58,29% | 1,99% | 0,47% | 9,70% | 6,31% | 0,23% | 12,16% |
| S-25 | ES | 18,42% | 4,29% | 65,93% | 3,01% | 4,52% | 0,46% | 3,36% | 0,00% | 7,99% |

**Table 1. Comparison of Children with Extreme Brain Types**

Nevertheless, the summarized mean of the three groups (empathizing, balanced and systemizing children) still shows that there are no significant differences in the behavior concerning their attentiveness. At this point, more data and deeper analyses are needed to clarify the results.

## DISCUSSION AND FIRST CONCLUSIONS

We assume that these dissenting results can have diverse reasons. So, possible bias of parents' answers in the questionnaire items maybe one of those, because of emphasis on the empathetic qualities of one's own child. In consequence, we decided to apply the EQ-SQ-Child Questionnaire to the kindergarten teachers as well.

Another reason could be that there are some parts in the setting that are more empathetic than planned: e. g. the organization of the children in small groups, or the teacher's behavior towards the children.

In addition to that, it could be that the children may show different behavior in their attentiveness and in the quality of their activity. Thus, we decided to code the videotapes using the assignment of "Leuven Involvement Scale for Young Children" (Laevers, 2007) according to the next research question: To what extent does the quality of activity

(engagement) of empathizing or systemizing children differ within the different learning environments?

At the actual stage, the basis for further the video-analyses is prepared. At the end of the whole study there will be empirical data from more than 100 children – their brain types and their time of attention in different learning environments – and about the quality of the children's activities. So we will be able to compare the scientific learning environments concerning "motivation" (in terms of paying attention) of systemizers and empathizers.

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## APPENDIX

EQ-SQ-Child Questionnaire

*Please complete by ticking the appropriate box for each statement*

| | | Definitely Agree | Slightly Agree | Slightly Disagree | Definitely Disagree |
|---|---|---|---|---|---|
| 1. | My child likes to look after other people. | | | | |
| 2. | My child often doesn't understand why some things upset other people so much. | | | | |
| 3. | My child doesn't mind if things in the house are not in their proper place. | | | | |
| 4. | My child would not cry or get upset if a character in a film died. | | | | |
| 5. | My child enjoys arranging things precisely (e.g. flowers, books, music collections). | | | | |
| 6. | My child is quick to notice when people are joking. | | | | |
| 7. | My child enjoys cutting up worms, or pulling the legs off insects. | | | | |
| 8. | My child is interested in the different members of a specific animal category (e.g. dinosaurs, insects, etc.). | | | | |
| 9. | My child has stolen something they wanted from their sibling or friend. | | | | |
| 10. | My child is interested in different types of vehicles (e.g. types of trains, cars, planes, etc.). | | | | |
| 11. | My child does not spend large amounts of time lining things up in a particular order (e.g. toy soldiers, animals, cars). | | | | |
| 12. | If they had to build a Lego or Meccano model, my child would follow an instruction sheet rather than "ploughing straight in". | | | | |
| 13. | My child has trouble forming friendships. | | | | |
| 14. | When playing with other children, my child spontaneously takes turns and shares toys. | | | | |
| 15. | My child prefers to read or listen to fiction rather than non-fiction. | | | | |
| | | Definitely | Slightly | Slightly | Definitely |

| | | Agree | Agree | Disagree | Disagree |
|---|---|---|---|---|---|
| 16. | My child's bedroom is usually messy rather than organized. | | | | |
| 17. | My child can be blunt giving their opinions, even when these may upset someone. | | | | |
| 18. | My child would enjoy looking after a pet. | | | | |
| 19. | My child likes to collect things (e.g. stickers, trading cards, etc.). | | | | |
| 20. | My child is often rude or impolite without realizing it. | | | | |
| 21. | My child knows how to mix paints to produce different colors. | | | | |
| 22. | My child would not notice if something in the house had been moved or changed. | | | | |
| 23. | My child has been in trouble for physical bullying. | | | | |
| 24. | My child enjoys physical activities with set rules (e.g. martial arts, gymnastics, ballet, etc.). | | | | |
| 25. | My child can easily figure out the controls of the video or DVD player. | | | | |
| 26. | At school, when my child understands something they can easily explain it clearly to others. | | | | |
| 27. | My child would find it difficult to list their top 5 songs or films in order. | | | | |
| 28. | My child has one or two close friends, as well as several other friends. | | | | |
| 29. | My child quickly grasps patterns in numbers in math. | | | | |
| 30. | My child listens to others' opinions, even when different from their own. | | | | |
| 31. | My child shows concern when others are upset. | | | | |
| 32. | My child is not interested in understanding the workings of machines (e.g. cameras, traffic lights, the TV, etc.). | | | | |
| 33. | My child can seem so preoccupied with their own thoughts that they don't notice others getting bored. | | | | |
| 34. | My child enjoys games that have strict rules (e.g. chess, dominos, etc.). | | | | |
| 35. | My child gets annoyed when things aren't done on time. | | | | |
| 36. | My child blames other children for things that they themselves have done. | | | | |
| 37. | My child gets very upset if they see an animal in pain. | | | | |
| 38. | My child knows the differences between the latest models of games-consoles (e.g. X-box, Playstation, Playstation 2 etc.,) or other gadgets. | | | | |
| 39. | My child remembers large amounts of information about a topic that interests them (e.g. flags of the world, football teams, pop groups, etc.). | | | | |
| | | Definitely | Slightly | Slightly | Definitely |

| | | Agree | Agree | Disagree | Disagree |
|---|---|---|---|---|---|
| 40. | My child sometimes pushes or pinches someone if they are annoying them. | | | | |
| 41. | My child is interested in following the route on a map on a journey. | | | | |
| 42. | My child can easily tell when another person wants to enter into conversation with them. | | | | |
| 43. | My child is good at negotiating for what they want. | | | | |
| 44. | My child likes to create lists of things (e.g. favorite toys, TV programs, etc.). | | | | |
| 45. | My child would worry about how another child would feel if they weren't invited to a party. | | | | |
| 46. | My child likes to spend time mastering particular aspects of their favorite activities (e.g. skate-board or yo-yo tricks, football or ballet moves). | | | | |
| 47. | My child finds using computers difficult. | | | | |
| 48. | My child gets upset at seeing others crying or in pain. | | | | |
| 49. | If they had a sticker album, my child would not be satisfied until it was completed. | | | | |
| 50. | My child enjoys events with organized routines (e.g. brownies, cubs, beavers, etc.). | | | | |
| 51. | My child is not bothered about knowing the exact timings of the day's plans. | | | | |
| 52. | My child likes to help new children integrate in class. | | | | |
| 53. | My child has been in trouble for name-calling or teasing. | | | | |
| 54. | My child would not enjoy working to complete a puzzle (e.g. crossword, jigsaw, word-search). | | | | |
| 55. | My child tends to resort to physical aggression to get what they want. | | | | |

(In: Auyeung et al., 2009, p. 11)