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Synaesthesia and Learning

A Differentiated View of *Synaesthetic Perceptional Awareness*

Essay by

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1. Introduction

Synaesthesia is a condition where the stimulation of one sense may elicit the activation of other senses. Synaesthetes, like me, perceive their surrounding differently from other people: music can be coloured, letters and numbers have genders and personalities, and shapes may have a taste. There are a great number of different types of synaesthesia. It is not a product of imagination, but a result of increased neuro-connectivity (Nunn, et al., 2002).

Since many years I am 'hunting' for synaesthetes. From the observations I made, I concluded that almost none of the synaesthetes I found was aware of this 'especial' form of perception. Therefore, I want to give an overview of the different factors that may have an influence on the overall *synaesthetic perceptual awareness.* I want to point out why and show different possibilities to reach a higher state of this kind of awareness.

Although many secrets remain recent researched solved many mysteries around this issue. Many assumptions based on single-case observations nowadays are rejected scientifically. Because of this I want to consider the question, if synaesthetes do have a general memory advantage and thus, how synaesthesia may aid in learning processes and where it has a detrimental effect on it. I also want to show different possibilities for school in dealing with synaesthesia, because school has the chance to help children to become aware of their sensory particularities.

2. What is Synaesthesia?

2.1 The neurological view

In this section I want to give a short overview about the current state of the neurological basis of synaesthesia. The first report of synaesthesia is dated to the year 1812 (Hochel & Milan, 2008). In the last decade, the interest in synaesthesia increased and a lot of empirical research was conducted to find out more about this truly fascinating issue.

One of the most common types is grapheme-color-synaesthesia (Simner & Hubbard, 2006) and it is also the most extensively studied form (P. H. Weiss, Zilles, & Fink, 2005). Imaging a letter can lead to the sensation of a color percept(Jansari, Spiller, & Redfern, 2006), also called photism. Recent studies showed an activation of the left human brain area V4 responsible for colors (Beeli, Esslen, & Jancke, 2008; Parslow, et al., 2002). This activation was not observed in non-synaesthetes although they were told to make conscious associations between letters and colors. This fact leads to the conclusion that

synaesthesia is real and not a product of imagination (Nunn, et al., 2002). Nowadays there is evidence that brain anatomy of synaesthetes may slightly differ from people without synaesthesia. It was shown that grapheme-color synaesthetes may have an increased grey matter volume in specific parts of the brain (Peter H. Weiss & Fink, 2008). Using Diffusion Tensor Imaging it was discovered that grapheme-color synaesthetes show an increased neuronal connectivity between different brain regions (Rouw & Scholte, 2007).

The word synaesthesia derives from Greek meaning "perceiving together". Synaesthesia is also found in arts, literature and reports of drug experiences like LSD consumption. Please do not confuse the genuine (true) synaesthesia (as I described before) with metaphoric or drug induced synaesthesias.

There are different characteristics that define what is genuine synaesthesia and what not (Cytowic, 2003; Jamie Ward, 2008). Therefore synaesthetic perception is considered to be a) stable over time, b) individually different and c) can be remembered. Further is supposed that synaesthesia d) seems to be normal for synaesthetes and e) cannot be learned.

The prevalence of synaesthesia within population seems to be much higher than assumed before (BaronCohen, Burt, SmithLaittan, Harrison, & Bolton, 1996): one out of 23 individuals in general population seems to have at least one type of synaesthesia (Simner, et al., 2006). Studies conducted in a Fine Art School (Domino, 1989) and in a secondary school (Mächler, 2004) revealed both a prevalence of 23% for grapheme-synaesthesia.

It is said, that synaesthetes are likely to be creative. An survey conducted in Australia found that 24% of the asked synaesthetes are employed in an artistic profession, whereas in the non-synaesthete population this applies only for 2% (Rich, Bradshaw, & Mattingley, 2005). In another study, synaesthetes and control subjects had to go trough tests which make creativity measurable. In some of these tests the synaesthetes performed significantly better, in others not. A broader analysis brought up that there may be a correlation between the number of synaesthesias and the outcome of the creativity test. %&(J. Ward, Thompson-Lake, Ely, & Kaminski, 2008). Ward et al. (2008) stated that creativity is not only a feature of art. He claimed that creativity is also needed in other fields than art, for example, science. Thus, not only artists can profit from the partially enhanced creativity that may be influenced by synaesthesia.

A study about the familial patterns of synaesthesia was conducted. They suggested that 42% of their probands have a first-degree relative with synaesthesia (Barnett, et al., 2008). Some researchers claim, that there is a bias between genders (Baron-Cohen, 1996) whereas others did not found a difference (Simner, et al., 2006). Interestingly latter ones stated that there is no known case of a father that has passed it on to the son. This underlines the possibility that synaesthesia might be an x-linked heritage trait. Studies run on monozygotic twins with different types of synaesthesia came to the conclusion that also other factors than genetic ones may have an influence on the development of synaesthesia (Hancock, 2006; Smilek, Dixon, & Merikle, 2005). However, one theory about the mechanisms leading to synaesthesia proposes that in the period after birth – also called neonatal phase of a child - some pruning processes in the brain might be inhibited. This could cause increased neuro-anatomical structures (Maurer & Mondloch, 2006). Neurologists think that the world of a newborn is quite different from that of an adult. %&(Mondloch & Maurer, 2004) go a step further by claiming that a newborn child only has one sense. They argue that the life of everybody begins with a form of synaesthesia and therefore this ability may remain in a way in synaesthetes.

2.2 Grapheme-color-synaesthesia

Grapheme-color-synaesthesia is one of the best studied forms of synaesthesia. People having synaesthesia often explain that reading, hearing or even imaging a letter or a number leads to a sensation of a specific color. This photism can differ in "form, spatial arrangement, transparency, solidity, intensity, and nuance" (Campen, 2009). It is recounted that graphemes also can have genders and personalities (Simner & Holenstein, 2007; Smiilek, et al., 2007). For me, for instance an 'A' is a blue wise woman and ***3*** is a green naughty boy. Some regularities were found for these synaesthetic photisms: higher numeric seems to be generally darker than small ones. 0 or 1 are often black and white (Kadosh, Henik, & Walsh, 2007). Some synaesthetes report to see these colors with mind's eyes, whereas others claim to see the colors outside, for example projected directly on the page of a book, therefore differentiated as either being "associator" or *"projector*" synaesthetes (Mike J. Dixon, Smilek, & Merikle, 2004).

Figure 1: from Ramachandran & Hubbard

There is also a frequency tendency for color-letter associations: for example, 43% of

synaesthetes see their ‘A’ in red (Simner, et al., 2005). A survey shows that there is no direct correlation between the colors of an alphabet book used in Australian schools and the synaesthetic color experiences (Rich, et al., 2005). Experiments report that the color perceived by the synaesthetes is rather induced by the semantic meaning of the grapheme than by its shape: looking at Figure 1, 'H' and 'A' are shaped in the same way. In fact, synaesthetes report to see both: the color for H and the color of the A, depending on what they are focusing. A differentiation between “higher” and “lower” synaesthetes is proposed referring to whether they do perceive colors for digits because of its conceptual or cognitive concept. That is to say, if the photism is induced trough the shape or through the semantic meaning, respectively (Ramachandran & Hubbard, 2001). This distinction is disputed %&(J. Ward, Li, Salih, & Sagiv, 2007).

%&(Meier & Rothen, 2007) conducted an interesting study: They showed colors to testing persons. Always when a specific color, let’s say *blue,* was shown, a loud noise was heard. In this way they got conditioned and showed a startle reaction when seeing this color. In a further step, black letters were shown. Synaesthetes showed a startle reaction seeing a letter that elicits the synaesthetic color *blue*. This may be an implication that synaesthetic perception also can be bidirectional: a color may induce the percept of a letter. Non-synaesthetes who have learned color-letter relations did not perform in such a way.

3. *Synaesthetic Perceptual Awareness*

As mentioned before synaesthesia is considered to be a frequent condition. Asking people for colored letters one might find a many synaesthetes. People who have synaesthesia answer in a very stereotypic way. Therefore one easily can get a first indication about a possible existence of synaesthesia. Almost all of these many synaesthetes I found in my family and my social circle were not aware of their synaesthesia nor did they know that this. May be, some of them do remember specific synaesthetic perceptions from childhood, but did not perceive that any more as adult. How one cannot note seeing colors when hearing music? It is about awareness.

Different sources consider awareness having an influence of the perception of synaesthesia (Campen, 2009; Kadosh & Henik, 2007). Confusingly this term is used differently. Kadosh and Henik (2007) suggest in their review that synaesthesia could be a function of awareness, rather than an all-or-nothing function. Further they delineate that

"the greater the abnormal neuronal connections, the greater the activity in the area that relates to the synaesthetic experience, thus enabling it to enter conscious awareness".

Campen (2009) provides another view of awareness: he claims that a lot of synaesthetes are not aware of synaesthesia because they do not pay attention to it. He describes becoming aware "takes a long time and a lot of concentration". He uses the term awareness as an attentional state, which can be increased by conscious efforts. Dixon & Smilek (2008), mention, that Campen "goes too far" in proposing "that everyone is a synaesthete and that many people just do not know it yet". I assume that there are a lot of synaesthetes who just don't knows it. But there are also non-synaesthetes who really do not have synaesthesia.

The use of the term *awareness* with respect to synaesthesia differs considerably: Is awareness only depending on neuronal connection or is it depending on what one is attentionaly focusing? In a way both, therefore a more differentiated view is required.

I propose *synaesthetic perceptual awareness* as an umbrella term. It contains different aspects which may have an influence on the degree of how intensive synaesthesia is perceived:

(i) strength of neurological connectivity, (ii) attentional awareness, (iii) Verbalization of synaesthetic perception, (iv) social interaction (v) Information and (vi) identification with synaesthesia.

synaesthetic strength of neuronal connectivity: unlike Kadosh et al. (2007) I believe that there is a threshold for synaesthesia becoming perceptive. It has been shown that the distinction of projectors and associators probably is based on levels of different strength of the neuronal connections (Hubbard, 2007; Rouw & Scholte, 2007).

In a way, everybody perceives the word with coupled senses or, according Ward (2008), with multisensory modalities. He predicates that senses do not work entirely separated. It looks like that in the brain of synaesthetes these multisensory modalities are stronger connected and therefore providing the opportunity being perceived aware. I suggest that being synaesthete or not may be depending on either the strengths of neurological structures have passed the threshold or not. This threshold may be individually different and depending on the type of synaesthesia, too.

Contradicionary to Kadosh et al. (2007) I claim that synaesthesia is an all-or-nothing function and graded as a level of neurological strength, which may develop in the neonatal

phase of a human being. High neuronal strength per se does not lead automatically to synaesthetic awareness but is the determining condition for being synaesthete or not.

synaesthetic attention: recent research clearly points out, that perceiving synaesthesia is a question of attention. Generally you do not perceive a stimulus you do not pay attention on. Thus, due to our limited attention capacity the induction of synaesthetic colors precedes the conscious perception of the grapheme (Sagiv, Heer, & Robertson, 2006). Music can elicit colored pattern, tastes and sensation of touch; due to our attentional limits a synaesthetes hearing it cannot pay attention on all facets of synaesthesia at the same time, he just can focus on some aspects of his perception.

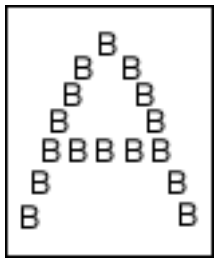

Figure 2: principle from Rich et al. (2005)

Synaesthetes have the ability to focus and therefore to 'zoom' into their synaesthetic perception. In a study underlining this, big letters consisting of little letters (e.g. A consisting of Bs, figure 2.) were presented to synaesthetes. They were asked which color they perceive. They explained that this depends on whether they were focusing either on the A or the Bs. So synaesthetic colors have an ambiguous character (Rich & Mattingley, 2003). Ward (2008, p. 83) created a nice metaphor for the ambiguity of synaesthetic perception: it is like you are looking through a window of a store; you may see what is inside the shop, but you also may see your image mirrored on the window glass.

In addition synaesthetes report that they cannot turn off the synaesthetic perception. The only way to do so is to ignore the main stimulus. Reading a book, a synaesthete won't perceive the music playing in the background; therefore he won't perceive the concurrent when perception not paying attention on the inducer. Synaesthetes do not perceive synaesthesia all the time due the limited attention capacity and because they do not always pay attention to it.

I suggest that *synaesthetic attention* determines of what aspect of synaesthesia one is focusing and in what frequency one pays attention to it in daily life. Latter may be very individual: some synaesthetes give a lot of regard to their synaesthesia during their life time whereas others hardly note it.

synaesthetic verbalization: *w*hen I am speaking about *synaesthetic verbalization* I refer to the question whether a synaesthete ever has thought, spoken or written about

synaesthetic perception. For example, thinking with inner speech ‘My number 3 is green’ or telling to somebody ‘the Sound of a piano is a blue dotted line’ are ways to verbalize it.

I propose an analogy for making more comprehensive the difference between attention and verbalization: it is like one is watching a picture on the wall with a flowery garden. You can watch the picture without verbalize it. This I assume to be the distinction between paying attention to synaesthesia (watch the picture) and verbalizing it (‘there are red flowers’). This verbalizing step offers the opportunity transforming synaesthetic images into a more conscious state and I suggest that it is an important first step in reaching *synaesthetic perceptual awareness.*

A synaesthete who never actively thought about colored digits will be surprised seeing colors when asked to think about graphemes. Casually I did meet M.S. in the street. At that time she never had given attention to color of digits nor had she ever verbalized it. Asking her for the color of A, she claimed directly that letters do not have colors. I told her to close her eyes and to imaging this grapheme. Astonished se reported that now it would be yellow…

We see in the first instance also synaesthetes may think, that digits do not have colors. With this example I want to show, that for synaesthetes it does not require a lot of attention is required to perceive synaesthesia and nor a big effort to verbalize is needed. But it looks like that they sometimes require an external impulse to recognize that.

Contrariwise non-synaesthetes do not relate colors to perceptions like music or graphemes. When they are told to, they make concrete associations, for example ‘Hearing music I see a flower with a bumble-bee’ or the colors they choose for digits are not constant over time. Non-synaesthetes do not show an aversive response against incongruity, they like digit ‘A’ in every color.

It is very difficult, if not impossible to paint what synaesthetes perceive. But it is a quite great exercise how to watch precisely synaesthetic images. Making a picture of synaesthetic colors may help to develop an ‘eye’ for better recognizing the details of it.

It might be that many synaesthetes only have verbalized some types of synaesthesia. I propose that being able to verbalize synaesthesia precedes a certain level of *attentional awareness*. On the other hand *synaesthetic verbalization* may lead to a higher level of *attentional awareness*.

synaesthetic information: there are a lot of synaesthetes who never heard about synaesthesia. Logically they cannot know that what they perceive is called synaesthesia,

nor are they able to claim being synaesthetes. Many people are relieved hearing that this phenomenon has a name and is not an illness or a psychological disorder. Or it is just satisfying to have an answer for all the questions that may have been arisen

It may also be easier to inform friends and family about a neurobiological issue with a name than to report about a 'foggy' world of colors that nobody might understand. Therefore one may be more open to talk about it. I claim that knowing synaesthesia helps to explore synaesthetic perception. 'Wrong' information about it, may have a contra wise effect.

synaesthetic identification: *identified* synaesthetes claim to have synaesthesia. I estimate that only a tiny part of synaesthetes do so. This step from an unidentified to an identified state may be influenced of external factors.

I observed many synaesthetes who have inhibitions to identify with synaesthesia. For a long time the current opinion was that it is quite an uncommon phenomenon (Cytowic, 2003; Emrich, Zedler, & Schneider, 2002). The problem may be that popular press refers on old estimations about prevalence and ignores the current state of research. Often journalistic articles contain exaggerated description about synaesthetes and synaesthesia often is presented as 'a scarce, especial firework of senses'. Thus, hearing about this 'strange phenomenon called synaesthesia' many synaesthetes construct false ideas about synaesthetic perception, because what they perceive seems to be normal for them and they do not consider this to be special. Furthermore the aspect that *synaesthetic awareness* is often excluded, this means, that one hardly reads in magazine articles that synaesthesia requires attention. Incomplete and unbalanced information may inhibit the step of identification and makes people believe that synaesthetes do fully perceive synaesthesia all the time. Furthermore, misleadingly they may think that every synaesthete knows about his particularity. In reality, synaesthetic perception is very subtle, depends on attention and needs to be perceived in an aware state of mind.

synaesthetic social interactions: this may have a strong influence of how synaesthetes identified or not, deal with synaesthesia.

Let's imaging a child that does not like number '6' because of its personality. Explaining this to its mother the reaction can be different: the mother may say that the child shall stop to speak such nonsense. It is imaginable that this child after being ridiculed could be inhibited to speak anymore about this or may develop an aversive

behaviour against this kind of perceptions and therefore won't pay a lot of attention to it. A disinterested answer of the mother perhaps would not have a great influence on the sensory behaviour of the child. It is imaginable that after this the child thinks that it is quite normal and that everybody sees digits in colors. An interested answer with the request to tell more about this would be theoretically the best manner to react. This hypothetic situation may not only apply for children, it also may happen to adults talking with their friends.

As I am asking all my peers for colored digits, I noted that synaesthetes which I informed before about synaesthesia have more difficulties to identify with their own synaesthesia than those who did not know, what I am asking about. The first ones often make statements like 'I do not have it like you do' or 'you may perceive that much more intensive than I do'. This may be due to *synaesthetic social interaction:* they know that I am 'the guy with synaesthesia' and therefore they think that they surely do not have the same. For me this reaction is quite habitual: although my ex-girlfriend S.A. confessed to see digits in colors, she denied being synaesthete two years long before she finally identified. And she was not the only one in my social circle who behaved in this way.

Campen (2009) describes, that also culture may have an influence of the percept of colors: the Desana, a tribe living in the Amazon area, perceive smells in colors. They call that "color energies". If the roots of these observations is a underlying genuine synaesthesia is not known.

Generally it is not that easy to express synaesthetic experiences with words, this may be due to the complexity of synaesthesia and because of the lack of words for describing it. Nevertheless, I consider one of the best ways for *synaesthetic verbalization* is to discuss with other people. Personally I claim that social exchange of synaesthesia may be a very satisfying way exploring this phenomenon. Therefore this may provide a new content for fascinating discussions with friends and family.

Every synaesthete have his own history in respect to the 'out-coming'. It seems to be quite simple to pay attention on synaesthetic perception. But it is not easy to have a high level of perceptual attention all the time. It needs a lot of time to enhance the amount of procentual syn perception

4. Synaesthesia and learning

4.1 Does synaesthesia lead to better memory capacities?

One can read in many books and newspaper articles that synaesthetes have superior memory abilities (Emrich, et al., 2002). Do they really? %&(Yaro & Ward, 2007) surveyed 46 synaesthetes: persons had to estimate, if their memory abilities are a) better than the average, b) like the average or c) worse than the average. 70% of them believed that their memory abilities were better than the mean. In a second task 16 synaesthetes and 16 matched controls had to pass for several memory tests: for example they had to recall words they heard remember digits from colored matrices and copy freely complex figures. Synaesthetes only showed a "minimal" better memory performance in recalling words but not in memorizing digits or copying complex figures. Similar studies did not reveal any difference between synaesthetes and non-synaesthetes in episodic memory. The conclusion they draw is that synaesthesia per se does not lead to a better memory. They explained individual differences by using synaesthesia as mnemonic strategy (Rothen & Meier, in press). Yaro and Ward (2007) stated that "synaesthesia plus training may lead to truly exceptional memory".

The myth that synaesthetes have generally a better memory may come from several single-case studies. Luria (Luria, 1968) describes synaesthete S. which was able to learn a matrix with 50 digits in a few minutes and to recall it 15 years later. Daniel Tammet (Tammet, 2006) is also a very special case: He is an autistic synaesthete. He broke the European record for reciting 22´514 digits without error. He also learned the islandic language within a week. There are further descriptions of synaesthetes with superior memory abilities (Cytowic, 1997; Smilek, Dixon, Cudahy, & Merikle, 2002) but one never knows to which degree synaesthesia is responsible for that. These single-case studies also reflect a selection-bias: people with an exceptional memory are more likely to attract the attention of a researcher (Rothen & Meier, in press). Thus, it is quite delicate to generalize these extraordinary memory skills to all people with synaesthesia.

4.2 positive influence of synaesthesia on learning

I suggest that there are several processes important for long-term storage which could be influenced beneficially by synaesthesia. In learning theory it is proposed that learning processes can be supported by using different modalities: Something only heard is not stored that easy as when it is seen, too (Ormrod, 2008). synaesthesia provides this

opportunity: several senses are activated at the same time. Synaesthetes do not only perceive historic dates like *1492* as a number. Trough the vivid nature of synaesthesia they also can perceive colors, genders or personalities as additional information. They automatically make several kinds of facts meaningful (Smilek & Dixon, 2008). I remember when I was a child my mind was full of mathematical synaesthetic perceptions. One example is the equation ***4 * 6 = 24:*** this mathematical term I perceived as the 'story of the ***4*** who was obligated to marry ***6'***. These personifications were elicited involuntary and were not created actively by myself. It supported me in dealing with numbers. Adding meaning to information and rely it onto prior knowledge is an aid in learning processes. Synaesthetic perception exactly does that, one only has to be aware of it.

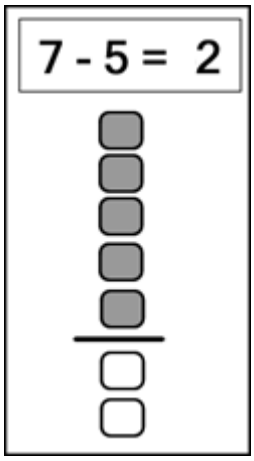

Figure 4: Visual image of synaesthete M., adapted from Mondon (2008)

Synaesthetes experience more vivid visual imagery than non-synaesthetes. Those images arise automatically and are consistent over time (Barnett & Newell, 2008; Spiller & Jansari, 2008). Making calculations, some synaesthetes see blocks piling up when calculating '7 – 5 = 2' (figure 4**)** or reading historic texts they see movies on their mind's eye. Additionally some see temporal concepts like weeks and decades spatially visualized (Price & Mentzoni, 2005) or they perceive the alphabet and the numbers arranged on a spatial line (Sagiv, Simner, Collins, Butterworth, & Ward, 2006). Ormrod (2008, p. 207) explains that "forming visual images can be a powerful means of storing information". Therefore, synaesthesia offers different beneficial opportunities to act as a mental aid in learning. But synaesthetic awareness is required and an reasonable implementation of the synaesthetic perception

Figure 5: My perception of the year; designed by (Mondon, 2008)

4.3 negative influence of synaesthesia on learning

There are a great number of studies (Rich & Mattingley, 2003; Smilek, et al., 2002), that claim that synaesthetes confronted with 'wrongly' colored digits can lead to a distracting effect. Synaesthetes report "feeling uneasy". They may claim that incongruent colors just do not match and sometimes they describe this as 'ugly'. Perceiving incongruently

colored graphemes also leads to affected judgments of emotional valence (Callejas, Acosta, & Lupianez, 2007). One study, examining synaesthete C., showed that she was faster to name an equation like ***2 + 3*** when it followed by the color that matched the result. Vice versa she was slower in naming the solution when there was an incongruent color presented (M. J. Dixon, Smilek, Cudahy, & Merikle, 2000).

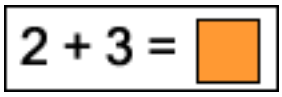

Figure 6: Adapted from Dixon et al. (2000)

The synaesthetic Stroop-Task works in a similar way like the ordinary Stroop-Task: colored digits are shown to probands consisting of synaesthetes and non-synaesthetes. The color of a digit was either a) neutral, b) congruent (subjectively right to the synaesthetes perception) or c) incongruent. For example, synaesthetes had more difficulties in naming the showed letter when it was presented in his subjective wrong color (Mills, Boteler, & Oliver, 1999). Further the incongruity-effect caused an enlargement of synaesthetes pupils (Paulsen & Laeng, 2006) .

C. provides a superior memory and has no problems to learn a matrix with 50 digits. In a second experiment she had to memorize 50 digits which were in a "wrong" color. She performed "considerably poorer" in this task (Smilek, et al., 2002). Contemporary, other studies did not found this incongruency effect in learning tasks with adults. This may be based on the fact that some synaesthetes report to mentally "translate" incongruent colors into congruent ones (Rothen & Meier, in press; Yaro & Ward, 2007) or because the task to learn 50 digits in general is very difficult.

%&(Green & Goswami, 2008) conducted experiments with children between 7 and 15 years. In one task they had to memorize digits in matrices. The synaesthetic children showed a significant decrease in recall when they had to learn the incongruent colored digits. Green et al. (2008) reported that incongruency has a "detrimental effect" on the performance of synaesthetic children. Maybe incongruent colors might have a stronger negative effect on memory in children than for adults, but further studies are needed to say more about this.

I remember an email of a 13-year-old boy. He claimed that his colored letters do confuse him and with this explication he reasoned his weakness in math. Ward (2008, p. 118) describes a survey conducted among synaesthetes which had to rate their strengths and their weaknesses. Interestingly, mathematics was claimed equally as strength and as weakness. Synaesthetes are individually different. One can't generalize their abilities neither their interests. Colored numbers do not automatically lead to a better comprehension of mathematical terms. For some synaesthetes colored numbers are more

confusing than beneficial. But I believe that assistance in dealing with these confusing effects of letters can be deleted through helping synaesthetes in arranging it, integrating it and thus learning to use the colors in a beneficial way.

4.4 The possible role of school

Campen (2009) states, that everybody has to "find it all" by his self, among other thing because "there is no educational program available to help". Not yet! According to estimations for prevalence, we can imaging that in every class of a primary school there are up to 3 synaesthetes. Educational system should not ignore them and their sensory skills. Further, school should provide assist in reaching a high *synaesthetic awareness*.

In this section I want to propose a possible attendance in school for synaesthetic children**.** I call this: ***Mediation of Synaesthesia*** and it could be applied for classes in schools.

The first element is a **Synaesthesia-Test**. The test of consistency is the "Gold-Standard" in doing this (Asher, Aitken, Farooqi, Kurmani, & Baron-Cohen, 2006). Synaesthetes choose always the same color for digits when they are asked to do so. Non-synaesthetes instead perform in an arbitrary way. Such a test can either be executed in a written form or computer-based. A written form of the Synaesthesia-Test should be accompanied with the computer based version to verify potential synaesthetes (Eagleman, Kagan, Nelson, Sagaram, & Sarma, 2007; Mächler, under construction). In this step children are confronted first time with the request of thinking about synaesthetic perceptions like colored digits. In this way one can divide into synaesthetes and non-synaesthetes.

The second part is **Information**: This can be a lecture or a simple presentation in the class about this issue. It is quite important that people know that synaesthesia exists and are informed about the current state of science in order being able to explain it to other people, for example to parents or to friends. This may be the point where synaesthetes identify themselves.

The third element consists of the **Workshop** which is thought to be conducted with the synaesthetic children. It shall show synaesthetes how to perceive synaesthesia attentionaly aware and how to verbalize it. With some practices it is possible to give an introduction of the different types of synaesthesia. For example one could play different sounds of different pitches for comparing the colors. Workshops may provide the opportunity going deeper into synaesthetic perception

The acquisition of synaesthetic mnemonic techniques is another interesting point. *Synaesthetic mediators* could teach different forms of how to use beneficially synaesthetic perception. The content of such a meeting could be: how to use colors to store vocabulary, how to deal with personalized numbers while calculating or how to exert spatial visual images in learning biology or history.

Continuing, it looks important to inform factually parents about the particularity of their child. Therefore the social interaction at home with family may enhance general awareness.nParents or teachers often do not know how to deal with synaesthesia. The children's book "Wenn die Vögel violett singen" (Mächler & Werhahn, in press) could be a way to enhance the synaesthetic exchange between parents and their children.

Of course this attendance of synaesthetes is not realized from one day to another. Not every teaching person is a synaesthete and synaesthesia yet is not included in the education of the teachers.

So what could teachers know and what should they respect? At least they should be informed that synaesthesia exists. Furthermore they should also have the comprehension that some educational methods, like the use of colored letters or numbers as a didactic help can have a detrimental effect on a minor part in the class. Supporting synaesthetes in using their synaesthetic associations would be better. Teachers could also motivate them in perceiving their synaesthesia more aware.

5. Conclusion

Current science is putting together the pieces of jigsaw to get a better understanding of synaesthesia and how our mind works in general. We have seen that the causes of synaesthesia may be due to neurological particularities. Synaesthetic perception highly depends on the level of *synaesthetic perceptual awareness*. This may be influenced by neuronal strength, attention, verbalization, social interaction, information and identification. Not every synaesthete perceives synaesthesia and most of them even don't know that this condition exists. Every synaesthete seems to have a proper history where the different aspects did have different influences on the *synaesthetic awareness*.

Many myths deriving from the last millennium were rejected by recent empiric studies: synaesthesia is not a rare condition neither do synaesthetes have a better memory per se.

But that is still spooking around in popular press. I propose that journalistic works should be based on recently discovered facts.

Synaesthetes sometimes can use their synaesthetic colors and visual images as mnemonic techniques. The presence of digits in an incongruent colour can have a distracting and displeasing effect for them.

Schools should provide *synaesthesia-mediation* for synaesthetic children. In this way school could help reaching higher synaesthetic perceptual awareness by supporting the sensory skills of the students. Trough information about this issue, synaesthetic students can be helped in getting aware of their abilities and to use them beneficially for learning. Furthermore it is quite important that teachers know that the use of colored digits as didactic tool can lead to a detrimental incongruity-effect. To reach these goals, learning and synaesthesia research should focus more on this aspects. Further, political school agenda should include *synaesthesia-mediation*, or at least provide information for teachers.

Synaesthesia is more than an easy way to memorize historic dates and it also is more than a neurological feature that scientists want to understand. Clarification of the facts around synaesthesia might not only have a positive influence on children's learning behaviours it also supports their self-confidence, because as I mentioned, some synaesthetes are afraid to be crazy, when they note, that not everybody is seeing music. My opinion is that synaesthesia can have a positive influence on the general development these personalities. Moreover, it is of importance to society and social connections. It is not that spectacular, neither are synaesthetes extraordinary people. However, perceiving synaesthesia is very gorgeous and to my mind more people do that more frequently. As we live in civilization, our modalities may be occupied by many disturbing stimuli. Synaesthesia developed in nature therefore there she may bloom most.

Everywhere you go, synaesthetes are around you and they are as normal as you are. Consider, you might be one, too….

What color is ***A*** for you?

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