Synaesthesia – Atypical Sensory Experiences

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SYNÆSTESI

– Atypiske sanseoplevelser

Synaesthesia

– Atypical Sensory Experiences

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Synæstesi er en sammentrækning af det Græske sam *(syn)* og følelse *(aisthesis)* og knyttes til et fænomen i den normale eller neurotypiske del af befolkningen. Ofte vil fænomenet blive beskrevet som samsansning, da en særlig sansekategori systematisk og automatisk udløser et aspekt fra en anden. Synæstesi er ikke et homogent fænomen, og der findes mange former, men en af de mest typiske er den form, der kaldes grafem-farve synæstesi. Her oplever folk, at når de ser et bogstav, så oplever de ikke blot en særlig form, der gør, at de kan identificere det (fx et "A"), men bogstavformen udløser også en klar oplevelse af en farve (fx ■).

Gennem årene har der været meget forskellige estimater af, hvor mange mennesker der er berørt af fænomenet fx 1 ud af 200.000 (Cytowic, 1994) mennesker. I dag er vi dog klar over, at det nok er et forholdsvist almindeligt fænomen, som ca. 1 ud af 23 personer besidder i forskellig grad (Simner, Mulvenna, Sagiv, Tsakanikos, Witherby, Fraser, & Ward, 2006)

The term 'synaesthesia' comes from the Greek *syn-* (with, together) and *aisthesis* (sensation, feeling) and is applied to a phenomenon found in the normal, or neurotypical, part of the population. The phenomenon is often described as simultaneous sensations, as a particular category of sensory stimulus will systematically and automatically trigger another kind of sensation as well. Synaesthesia is not a homogeneous phenomenon; many different forms exist, but one of the most typical manifestations is the variant known as grapheme-colour synaesthesia. Synaesthetes of this kind find that when they see a letter, they not only perceive a specific form that allows them to identify that particular letter (e.g. an 'A'); the shape of the letter also triggers a clear sensation of a colour (e.g. ■)

Over the years, scholars have produced very different estimates of how many people are affected by the phenomenon, with one study (Cytowic, 1994) placing the number at 1 in 200,000 people. Today, however, we are aware that this is probably a fairly common phenomenon, affecting approximately 1 out of 23 people to varying degrees (Simner, Mulvenna, Sagiv, Tsakanikos, Witherby, Fraser, & Ward, 2006)

"Umiddelbart tænker de fleste nok, at vi alle oplever verden på samme vis".

I lang tid mente man, at der var en genetisk komponent involveret i forhold til det at udvikle synæstesi, fordi man i snit så seks kvinder, for hver gang man fandt én mand med synæstesi (Baron-Cohen, Burt, Smith-Laittan, Harrison, & Bolton, 1996). Det var derfor oplagt at tænke, at hvis synæstesi var knyttet til x-kromosomet, ja så ville der automatisk være flere kvinder (med 2 x-kromosomer) end mænd (med et x og et y kromosom), der udviste fænomenet. Men man har endnu ikke systematisk kunne isolere klar genetisk evidens for synæstesi. Ligeledes har det vist sig, at det oprindelige kønsskel nok var kunstigt, da mænd, måske i mindre grad end kvinder taler om, hvorledes de oplever verden.

Ofte fandt man deltagere ved at annoncere efter dem i aviser o.l. (fx Baron-Cohen, et al., 1996), men for nyligt, begyndte en gruppe forskere at undersøge børn i samarbejde med folkeskolerne. Da man her ikke længere så den systematiske kønsvægtning, begyndte man at stille spørgsmål ved de tidligere teorier omkring kønsforskelle. Simner og Bain (2013) foreslog, at kvinder måske i langt højere grad end mænd taler om, hvordan de oplever verden omkring dem, og at de derved har større sandsynlighed for at opdage, at de på nogle punkter afviger i deres oplevelser fra andre.

For a long time, researchers believed that developing synaesthesia was partly governed by genetics because they would, on average, find six women for each one man with synaesthesia (Baron-Cohen, Burt, Smith-Laittan, Harrison, & Bolton, 1996). This quite naturally prompted the idea that if synaesthesia was linked to the X chromosome, you would automatically see more women (who have two X chromosomes) than men (who have one X and one Y chromosome) exhibiting the phenomenon. But as yet, no studies have systematically isolated clear evidence of a genetic component of synaesthesia.

Likewise, it has turned out that the difference between genders may have been the result of artificial conditions, caused by a tendency for men to be less prone than women to talk about how they perceive and experience the world.

In the past, study participants were often found by advertising in newspapers and the like (e.g. Baron-Cohen, et al., 1996), but recently, a group of researchers began examining children in collaboration with primary schools. Since this eliminated any systematic gender bias, scholars began to question the previous theories regarding gender differences. Simner and Bain (2013) suggested that women may be much

Dermed peger de på, at en større andel af mænd ikke er klar over, at de har synæstesi sammenholdt med kvinder. Umiddelbart tænker de fleste nok, at vi alle oplever verden på samme vis. Denne opfattelse forstærkes af, at vi ikke reelt set har direkte adgang til, hvordan andre mennesker oplever verden (Nagel, 1974). Hvis vi ikke decideret taler om vores oplevelser sammen med andre, der kunne have en anden oplevelse end vores, forbliver vi i troen om, at andre selvfølgelig oplever verden præcis, som vi selv gør (fx at bogstaver naturligt også har en medfølgende farveoplevelse).

For et par år siden blev mange af os, på de sociale medier, konfronteret med, hvor store forskelle der kan være i den måde, vi ser verden på. En mor, Cecilia Bleasdale lagde et billede op af en kjole, der senere blev kendt under #TheDress. Hun havde fundet kjolen den 7. februar 2015 (Wallisch, 2017) i forbindelse med, at hun skulle til datterens bryllup. Et billede af kjolen sendes i første omgang til datteren, men der er imidlertid uenighed om,

more likely than men to talk about how they perceive the world around them, meaning that they are more likely to discover that in certain respects, their experiences differ from those of others. Thus, they pointed out that compared to women, a larger proportion of men are unaware that they have synaesthesia. Most people tend to assume that we all experience the world in the same way. This view is reinforced by the fact that none of us can directly experience how other people perceive the world (Nagel, 1974). If we do not specifically talk about our experiences, discussing them with others who might have a different perception than our own, we quite naturally retain our belief that others experience the world exactly as we do (for example, we may think everyone associates letters with a particular colour).

A few years ago, social media confronted many of us with just how differently we sometimes see the world. A mother, Cecilia Bleasdale, posted a picture of a dress that would later simply become known as #TheDress. She found the

Figur 1. Billede af #TheDress, der tydeliggør hvor forskelligt folk kan opleve farverne. Kjolen er i virkeligheden blå og sort.

Fig. 1. A picture of #TheDress, demonstrating how people can see colour very differently. In reality, the dress is blue and black.

hvilken farve den egentlig har. Nogle mener, at kjolen er sort og blå, mens andre hævder, at den er hvid og guld (se Fig. 1). Nuancerne i denne opdeling kan endda variere yderligere, men groft set er der omkring 2/3, der mener, at kjolen er sort og blå, mens den sidste 1/3 ser den som hvid og guld (Lafer-Sousa, Hermann, & Conway, 2015). Dette fænomen demonstrerer på fineste vis, at vores hjerner laver en tolkning på den information, den får gennem sanserne – og denne tolkning kan variere meget mellem individer og grupper (Gegenfurtner, Bloj, & Toscani, 2015).

Ligeledes ser vi, at mange først opdager, at de har synæstesi i de tidlige ungdoms- og voksenår. Gennem samtaler om, hvordan man fx oplever farver for ord og navne, opstår der en erkendelse om, at ikke alle har samme farveoplevelse, og at de fleste rent faktisk ikke har en særlig farve knyttet til ord og navne.

Som nævnt, er synæstesi et meget heterogent fænomen. Gennem de sidste år har Sean Day på hans hjemmeside (http://www.daysyn.com/) samlet folks udsagn om forskellige former for synæstesi og er i dag oppe på mindst 80 forskellige former (baseret på 1.143 folk, der hævder at have synæstesi; 10-01-2019). Fælles for dem alle er dog en atypisk samtidig oplevelse (fx en bestemt farve) tilknyttet en bestemt kategori (fx bogstav- eller talformer).

Denne oplevelse er typisk stabil over tid (Witthoft & Winawer, 2006; se dog Simner & Bain, 2013; Sørensen, Nordfang, & Ásgeirsson, 2016). Den atypiske oplevelse af fx farve sker automatisk og uden nogen form for anstrengelse (fx Laeng, 2009). Ligeledes vil mange synæstetikkere have mere end én form for synæstesi. Nedenfor er et eksempel fra en ung pige 'AR', som har tegnet hendes oplevelser af geometriske former og tal (Fig. 2).

dress on 7 February 2015 (Wallisch, 2017) and planned to wear it for her daughter's wedding. She first sent the picture only to her daughter, but the family soon found that they – and many others – disagreed about its colouring. Some said that the dress is black and blue, while others claimed it to be white and gold (see Fig. 1). The finer nuances of this discussion introduced even greater variety, but roughly speaking we may say that approximately two-thirds see the dress as black and blue, while the remaining one-third see it as white and gold (Lafer-Sousa, Hermann, & Conway , 2015). The phenomenon is an excellent demonstration of how our brains interpret the information they get through our senses – and how this interpretation can vary widely between individuals and groups (Gegenfurtner, Bloj, & Toscani, 2015).

We also see that many people do not discover they have synaesthesia until early adolescence or adulthood. For example, conversations about seeing colours when hearing specific words or names may prompt synaesthetes to realise that not everyone experiences colour like they do, and that most people do not associate particular colours with given words and names. As we have already heard, synaesthesia is a very heterogeneous phenomenon. In recent years, Sean Day has compiled statements on various forms of synaesthesia on his website (http://www.daysyn.com/), having by now identified at least eighty different forms (based on 1,143 people claiming to have synaesthesia; 10-01-2019). They all, however, share one trait: associating an atypical sensation (for example that of seeing a specific colour) with a particular category of stimuli (such as letters or numbers).

These sensations are typically experienced consistently over time (Witthoft & Winawer, 2006; see, however, Simner & Bain, 2013;

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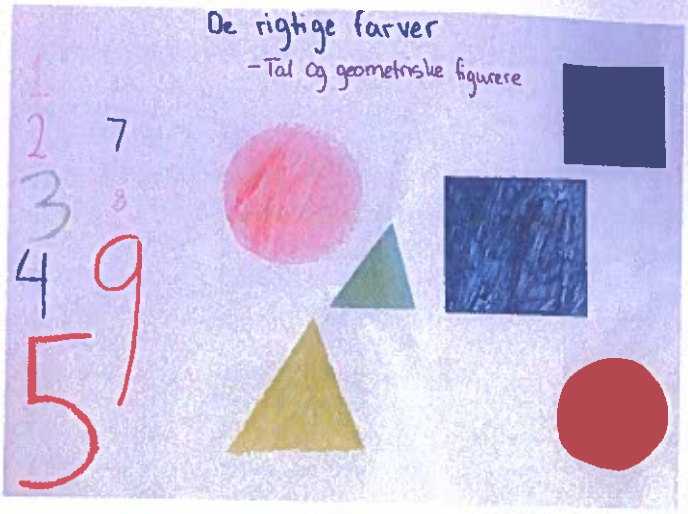
Figur 2. Tegning fra en ung pige med synæstesi (AR), som bl.a. oplever, at former og tal har farver. Desuden har tal forskellige størrelse, som ikke nødvendigt er kædet sammen med deres numeriske værdi (fx er 5 større ned 6).

Fig. 2 Drawing by a young girl with synaesthesia (AR), who sees specific shapes and forms as having specific colours. She also sees numerals in different sizes, which do not necessarily reflect their numerical value (for example, 5 is larger than 6).



Geometriske former har, for hende, en klar farveoplevelse. Ser hun en firkant, oplever hun den som blå, en trekant som grøn og så fremdeles. I tillæg opleves mindre former som en mere mættet farveoplevelse. Udover farveoplevelser for geometriske former oplever hun også, at både tal og bogstaver har deres egne farver. Disse relaterer sig ikke nødvendigvis til noget eksternt i hendes omgivelser. Fx har hun en oplevelse af, at tal har forskellige størrelser, alt efter deres identitet og ikke deres numeriske værdi. Et tal som 6, bryder hun sig eksempelvis ikke om, fordi det *"er så lille og gråt, og derfor ofte vanskeligt at se"*, hvorimod 5 og 9 er mere rare, da de er store og orange.

AR's beskrivelser er meget typiske for folk med synæstesi. Dels beskriver hun, at hun *"ser"* farverne eller et tal som lille, og dels har hun en værdiladning, når hun taler om, at noget er enten et *"rart"* tal eller at tegningen illustrerer

Sørensen, Nordfang, & Ásgeirsson, 2016). For example, such atypical sensations of colour occur automatically and without any kind of effort (e.g. Laeng, 2009). Likewise, many synaesthetes have more than one form of synaesthesia. In the example below, a young girl, 'AR', has drawn how she perceives geometric shapes and numbers (Fig. 2). For her, geometric shapes are firmly associated with particular colours. If she sees a square, she perceives it as blue, a triangle is green, and so on. She also perceives smaller forms as more saturated in colour. In addition to associating geometric shapes with colours, she also finds that numerals and letters have their own colours. These colours do not necessarily relate to anything in her external surroundings. For example, she perceives numbers as different in physical size depending on their visual identity rather than their numerical value. And she does not like the number 6 because it is 'so

"de rigtige farver". Udover denne type af subjektive udsagn, så kan vi også objektivt måle forskelle mellem folk, der har synæstesi og folk, der ikke har. Tester vi eksempelvis, hvorledes grafem-farve synæstetikkere processerer bogstaver, kan vi se, at bogstaver der vises med den farve, de oplever processeres både hurtigere og mere effektivt, end hvis vi viser det med en anden farve, der ikke passer med det oplevede (Sørensen & Ásgeirsson, 2013; Ásgeirsson, Nordfang, & Sørensen, 2015).

Hvad er det, der gør at nogle har synæstesi, mens andre ikke lader til at have det? Som nævnt ovenfor har man tidligere mistænkt, at synæstesi har en genetisk komponent baseret på den skæve kønsfordeling, man så (fx Baron-Cohen, et al., 1996). Ligeledes har familiestudier peget på, at fænomenet optræder indenfor familier, som jo deler genetisk materiale, med stor hyppighed (Barnett, Finucane, Asher, Bargary, Corvin, Newell, & Mitchell, 2008). Men er man opvokset i en familie med et familiemedlem, som har synæstesi, er det vanskeligt helt at isolere fænomenet til genetik. Det er muligt, at familiemedlemmet ind i mellem taler om de synæstetiske oplevelser, hvorigennem det er miljøet og ikke arvematerialet, der spreder fænomenet videre. Dette støttes yderligere af evidens for, at de farveassociationer man kan have for bogstaver indimellem kan relateres til det miljø, man er opvokset i. Eksempelvis har man flere gange demonstreret at synæstetikkere, der er vokset op med farvede køleskabsmagneter formet som bogstaver har farver, der knytter sig til netop disse (Witthoft & Winawer, 2006; Witthoft, Winawer, & Eagleman, 2015).
Men selvom nogle etablerer deres synæstesi gennem interaktion med omgivelserne, så er det stadigt kun en lille del af befolkningen, der udvikler synæstesi. Indenfor de seneste år har en række forskere forsøgt at træne synæstesi

small and grey, often making it difficult to see', whereas 5 and 9 are 'nicer' because they are big and orange.

AR's descriptions are very typical of people with synaesthesia. For example, she describes 'seeing' colours or perceiving a given number as small, and she also attributes specific values to certain impressions, for example by describing a number as 'nice' or stating that her drawing depicts the 'right' colours. But subjective statements are not the only way of recording differences between people who have synaesthesia and those who do not – we can also measure objective differences. If, for example, we test how grapheme-colour synaesthetes process letters, we see that test subjects process letters appearing in the colours described by them faster and more efficiently than if we show them letters in colours that do not match their descriptions (Sørensen & Ásgeirsson, 2013; Ásgeirsson, Nordfang, & Sørensen, 2015).

So why do some people have synaesthesia while others don't seem to have it? As we have touched upon, scholars have previously suspected that synaesthesia is partly due to genetic components, a thesis based on the skewed gender distribution observed (e.g. Baron-Cohen, et al., 1996). Likewise, family studies have indicated that the phenomenon often recurs within the same families, which of course would share genetic material (Barnett, Finucane, Asher, Bargary, Corvin, Newell, & Mitchell, 2008). However, when assessing subjects who grew up in a family in which one or more members have synaesthesia, completely isolating the genetic component becomes difficult. The family member with synaesthesia may talk about his or her synaesthetic experiences, which may cause the phenomenon to spread as an environmental factor rather than a genetic one. This position is supported by evidence

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hos folk, der ikke i forvejen har synæstesi (Bor, Rothen, Schwartzman, Clayton, & Seth, 2014; Colizoli, Murre, & Rouw, 2012; Meier, & Rothen, 2009). Selvom resultaterne med tiden er blevet bedre i disse studier, så er det endnu ikke lykkedes at etablere synæstesi. Dette kan pege på, at det måske kræver en særlig biologisk profil, for at udvikle synæstesi, men det kan også være, at der er noget særligt omkring træningen, som tidligere studier endnu ikke har adresseret.

Der findes særligt fire interessante aspekter, som vi aktuelt undersøger på Aalborg Universitet; mængden, motivationen, læringskategorien og alder. Selvom der er en hel del træning ved at læse fem bøger med farvede bogstaver (Colizoli, et al., 2012) eller forskellige farve-bogstavsopgaver, hver dag i ni uger (Bor, et al., 2014), så er det stadigt langt fra den træning folk laver, når de lærer alfabetet eller et nyt sprog. Udover mængden, så kan folks motivation og aspiration måske også betyde noget for, hvorvidt man etablerer synæstesi. Ved grafem-farve synæstesi, kan farver måske hjælpe med at etablere og adskille de nye kategoriseringer, når vi som børn lærer alfabetet. Ligeledes er det nærliggende, at motivation og brugbarheden af at udvikle læsefærdigheder, er vigtigere for os som individer,

that the colours associated with letters may sometimes reflect the environment in which you grew up. For example, several studies have demonstrated that synaesthetes who grew up with coloured fridge magnets shaped like letters have associations that correspond to those magnets (Witthoft & Winawer, 2006; Witthoft, Winawer, & Eagleman, 2015).

But even though some establish their synaesthesia through interaction with their environment, we still see that only a small part of the population develops synaesthesia. In recent years, a number of researchers have tried to train synaesthesia in people who do not already have it (Bor, Rothen, Schwartzman, Clayton, & Seth, 2014; Colizoli, Murre, & Rouw, 2012; Meier, & Rothen, 2009). While the results of these studies have improved over time, they have not yet succeeded in establishing synaesthesia. This may indicate that a special biological profile is required in order to develop synaesthesia, but it may also simply mean that certain aspects of the training have not yet been addressed.

Four interesting aspects of this issue are currently being investigated at Aalborg University: motivation, learning category, age, and the amount of training involved. While it is

end at lave en arbitrær træningsopgave i et laboratorium. Ligeledes kan det være, at vi ikke udvikler reel synæstesi for materiale, der allerede er indlært (fx at knytte en farve til bogstaver efter at vi har lært alfabetet), men måske kræver det, at vi står ansigt til ansigt med indlæringen af en helt ny type elementer (fx at lære et nyt skriftsprog, som kinesisk eller koreansk). Endeligt, så kan indlæringstidspunktet også betyde noget, da den menneskelige hjerne er mere plastisk i de tidlige leveår. Det er også her vi etablerer de perceptuelle strategier, som vi bruger i vores hverdag, hvilket vi ser træde frem ved fx #TheDress (Sørensen, 2019). Perceptuelle strategier der kan variere substantielt mellem forskellige mennesker.

Vil du vide mere, så besøg Center for Kognitiv Neurovidenskab på http://ccn.aau.dk – og kunne du tænke dig at deltage i vores undersøgelser, kan du tilmelde dig på: http://syn.aau.dk. Her kan du også teste din grafem-farve synæstesi online, for direkte link: https://goo.gl/K3eXmh (bemærk store og små bogstaver).

true that substantial effort goes into reading five books with coloured letters (Colizoli, et al., 2012) or carrying out various colour-letter tasks every day for nine weeks (Bor, et al., 2014), the level of work is still much less extensive than the efforts made when learning the alphabet or a new language. Besides the quantity of training involved, individual motivation and aspirations may also affect whether test subjects establish synaesthesia. As regards grapheme-colour synaesthesia, colours may help establish and separate the various new categories we develop as children when learning the alphabet.

Looking at motivation, the usefulness of developing reading skills is greater for us as individuals than doing arbitrary exercises in a laboratory. It may also be that we do not develop real synaesthesia in relation to material that has already been learned (for example, we may not be able to associate letters with colours after we have learned the alphabet); perhaps it requires us to face learning something brand-new to us (for example a form of written language entirely unfamiliar to us; in Denmark this may be Chinese or Korean). Finally, age may play a part, as the human brain is more malleable during the early years of life. This is when we establish the perceptual strategies that we use in our everyday life – the kind of strategies demonstrated in the case of #TheDress (Sørensen, 2019). Such perceptual strategies can vary substantially from one person to the next.

To find out more, visit the Centre for Cognitive Neuroscience at http://ccn.aau.dk – and if you would like to participate in our studies you can register at: http://syn.aau.dk. You can also test your own level of grapheme-colour synaesthesia online; use the direct link: https://goo.gl/K3eXmh (note upper and lower case letters).

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Ásgeirsson, Á. G., Nordfang, M., & Sørensen, T. A. (2015). *Components of attention in grapheme-color synesthesia: A modeling approach.* *PloS one*, 10(8), e0134456.

Barnett, K. J., Finucane, C., Asher, J. E., Bargary, G., Corvin, A. P., Newell, F. N., & Mitchell, K. J. (2008). *Familial patterns and the origins of individual differences in synaesthesia.* *Cognition*, *106*(2), 871-893

Baron-Cohen, S., Burt, L., Smith-Laittan, F., Harrison, J., & Bolton, P. (1996). *Synaesthesia: prevalence and familiality.* *Perception*, *25*(9), 1073-1079.

Bor, D., Rothen, N., Schwartzman, D. J., Clayton, S., & Seth, A. K. (2014). *Adults can be trained to acquire synesthetic experiences.* *Scientific Reports*, *4*, 7089.

Colizoli, O., Murre, J. M., & Rouw, R. (2012). *Pseudo-synesthesia through reading books with colored letters.* *PloS one*, *7*(6), e39799.

Cytowic, R. (1994). *The Man who Tasted Shapes.* New York: Archer/ Putnam.

Gegenfurtner, K. R., Bloj, M., & Toscani, M. (2015). *The many colours of 'the dress'.* *Current Biology*, *25*(13), R543-R544.

Lafer-Sousa, R., Hermann, K. L., & Conway, B. R. (2015). *Striking individual differences in color perception uncovered by 'the dress' photograph.* *Current Biology*, *25*(13), R545-R546.

Laeng, B. (2009). *Searching through synaesthetic colors.* *Attention, Perception, & Psychophysics*, *71*(7), 1461-1467.

Meier, B., & Rothen, N. (2009). *Training grapheme-colour associations produces a synaesthetic Stroop effect, but not a conditioned synaesthetic response.* *Neuropsychologia*, 47(4), 1208-1211.

Nagel, T. (1974). *What is it like to be a bat?* *The Philosophical Review*, 83(4), 435-450.

Simner J., Mulvenna C., Sagiv N., Tsakanikos E., Witherby S. A., Fraser C., & Ward J. (2006). *Synaesthesia: The prevalence of atypical cross-modal experiences.* *Perception*, 35, 1024-1033.

Simner, J., & Bain, A. E. (2013). *A longitudinal study of grapheme-color synesthesia in childhood: 6/7 years to 10/11 years.* *Frontiers in Human Neuroscience*, *7*, 603.

Sørensen, T. A., & Ásgeirsson, Á. G. (2013). *Sanseoplevelser i Hjernen-Synæstesi.* *Psykologisk Set*, 30(89), 23-29.

Sørensen, T. A., Nordfang, M., & Ásgeirsson, Á. G. (2016). *Gradual consolidation of synesthesia during adolescence: A case study.* *Journal of Vision.* https://doi.org/10.1167/16.12.460

Sørensen, T. A. (2019). *Kunst, synæstesi og individuelle forskelle i perception.* In Kruuse, C. & Petersen, N. C. (Ed.), *Den Kunstneriske Hjerne.* (pp. 66-77). HjerneForum.

Wallisch, P. (2017). *Illumination assumptions account for individual differences in the perceptual interpretation of a profoundly ambiguous stimulus in the color domain: "The dress".* *Journal of Vision*, 17(4):5, 1-14, doi:10.1167/17.4.5.

Witthoft, N., & Winawer, J. (2006). *Synesthetic colors determined by having colored refrigerator magnets in childhood.* *Cortex*, 42(2), 175-183.

Witthoft, N., Winawer, J., & Eagleman, D. M. (2015). *Prevalence of learned grapheme-color pairings in a large online sample of synesthetes.* *PLoS ONE*, 10(3): e0118996