



## **AM I FUNNY NOW?**

The Neurological Basis of Humor Styles

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### Abstract

The present thesis will provide an overview of how the four humor styles, affiliative, self-enhancing, aggressive, and self-defeating humor, are connected to different brain areas. The thesis will also include an overview of how humor in general, and especially three factors of humor including, processing, appreciation, and comprehension is connected to different brain areas. The present study found a connection between these three factors of humor and activation in the prefrontal cortex (PFC) and inferior frontal gyrus (IFG). The four humor styles were all connected to activity in the midbrain and nucleus accumbens (NAc), though they were found to differ in other parts of the brain. Affiliative humor and self-enhancing humor are humor styles found to share activation of similar brain areas, whereas self-enhancing and aggressive humor was found to the least extent share activation of the same brain areas. No neural differences in relation to the four humor styles have been found between men and woman, or between cultures.

*Keywords:* humor, humor styles, affiliative humor, self-enhancing humor, aggressive humor, self-defeating humor

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## 1. Introduction

Humor is a deep-rooted character trait among humans and has been a part of us for a very long time. We start to develop our sense of humor as early as four months of age when we start laughing and smiling. It is part of our social development and helps us understand other peoples' emotions and intentions in life (Lyons & Fitzgerald, 2004).

During the 20<sup>th</sup> century, there has been a variety of research focusing on different factors of humor. Much of the research focuses on individual differences and if humor has a beneficial effect on physical and psychological health and well-being (Martin, Puhlik-Doris, Larsen, Gray, & Weir, 2003). For the past 20 years, increasing amount of humor research focusing on the neurological pathways has occurred. Both EEG (Wang, Kuo, & Chuang, 2017) and fMRI (Tian et al., 2017; Chan et al., 2018) studies have been conducted in this purpose. Humor research has during the last decade focused on what drive people to use one type of humor style rather than another, and also the purpose of utilizing that certain humor style (Chan et al., 2018). Recent years of research has provided much more information about the neural processing of humor and different humor styles. Therefore, a review of these recent findings, may summarize and give an overall perspective of the neural processes of humor styles.

Rod A. Martin is a professor of psychology, specialized in clinical psychology and most of his work and articles aim at the field of humor, especially how it can be related to psychological well-being and stress (Uwo, 2019). According to Martin et al. (2003), humor can be divided into different categories depending on how it is being used and whom it is meant for. To categorize the different humor styles, Martin et al. (2003) built a 2x2 model of humor. The first part defines which type of humor it is, and is based on if the humor is being used to enhance oneself or ones' relationship with other people. The other part defines what type it is, and crosses the first section, it is if the humor that is being used is relatively kind and benign, or harmful and detrimental. From this model, the four humor styles are defined -

affiliative, self-enhancing, aggressive, and self-defeating humor (Martin et al., 2003).

Affiliative humor is used to enhance ones' relationship with other people and is most often kind to oneself. Self-enhancing humor is used to enhance oneself and is also most often kind to other people. Aggressive humor is used to enhance oneself while being detrimental to other people, and self-defeating humor is being used to enhance ones' relationship with others while being detrimental to oneself (Martin et al., 2003).

Lyons and Fitzgerald (2004) found that individuals who are diagnosed with autism or Asperger syndrome have reduced capacity of understanding and expressing humor. This can be an indicator of humor sharing some- or all- brain regions as other emotions.

Further back in history humor was seen as always positive because it involved e.g. laughing, but in time with research growth of the four humor styles, which include both benign and detrimental humor styles, researchers started to investigate more negative forms of humor as well. The humor styles have also been found to be connected to a variety of other character traits within us humans (Greengross, Martin, & Miller, 2011). The connection between humor styles and other character traits can be a way to understand why some people tend to use more detrimental humor while others tend to use more benign humor. If an individual uses detrimental humor, it may be because he also has lower levels of openness and agreeableness (Greengross et al., 2011). Humor is expressed or experienced on an everyday basis and according to the author, identification of specific brain connections between the four humor styles could prevent negative emotions for example aggression or anxiety. For this reason, studying humor concerning neural connections is of great importance and may result in a future preventative method for mental illness and unhappiness.

### **1.1. Aim and Structure**

This thesis aims to give a review of how the four humor styles are connected to activity in different brain areas. To be able to answer this question, the thesis will include a general

view of how humor in general, is built up in the brain. Furthermore, the following will be discussed: if all studies within the field of humor and the brain agree upon which brain area is most involved in each humor style or if the results contradict each other. Another question is if only the white matter structure of the brain is involved in the different humor styles (Wu, Zhong, Chan, Chen, & He, 2018), or if there are other components involved. This review will be built on previous research and findings within the field of humor style research, and although some questions have already been answered in previous research, others remain.

To discuss and answer these questions a thorough description of humor and the different humor styles will be provided. Following this, research on how humor and the different humor styles are being processed in the brain will be presented and explored in separate sections of the thesis. The thesis will conclude with a discussion of the presented material concerning the aim as well as a general discussion of the research field including possible future research.

## **1.2. Method**

This thesis is built up from articles mainly found from searches through Web of Science, and Google Scholar. The searching included keywords such as ‘‘humor’’, ‘‘humor styles’’, ‘‘humor+neuro’’, and ‘‘humor styles+brain’’. Furthermore, the articles were selected based on suitability in relation to this thesis, publication year, and citation rate. The articles were then sorted into three categories: humor in general, humor styles, and neural connections. The categorization was conducted to facilitate the review of articles and decide which to exclude and include in the thesis.

## **2. Background**

### **2.1. Humor**

Humor is a broad term that can be described as a sort of expression and a way to experience funny and amusing things and is a unique characteristic of us humans (Chan,

Chou, Chen, & Liang, 2012; Goel & Dolan, 2001; Lyons & Fitzgerald, 2004; Nakamura et al., 2018; Vrticka, Black, & Reiss, 2013b). It can also be used as an emotional response and be expressed vocally with e.g. laughter (Martin & Ford, 2018; Jiang, Li, & Hou, 2019).

Laughter is one of the most unique traits we have as human beings that few other animals have (Martin et al., 2003). Humor can be a way to create and increase positive emotions in life, but also a way to decrease negative ones. It is referred to as an important social skill that can help people to build and strengthen social bonds and relationships, but it can also be used as a defense mechanism and a way to handle difficult situations (Martin, 2010). Humor is often defined as a sort of play even though it can be a part of more serious functions, such as cognitive, social, and emotional (Martin, 2010). As an example, the cognitive parts of humor require the ability to remember or make up jokes. The social parts are connected to a habitual behavior to bond with other people, and the emotional parts can be when humor is being used as a coping strategy (Martin et al., 2003). Humorous people are described to have a ‘‘sense of humor’’. It is a concept that was developed in the 19<sup>th</sup> century and it stands for the more positive forms of humor (Martin, 2010). Sense of humor is one out of of 24 character-strengths in positive psychology, by Peterson and Seligman (2004). Peterson and Seligman describe a person with a sense of humor:

‘‘One who is skilled at laughing and gentle teasing, at bringing smiles to the faces of others, at seeing the lighter side, and at making (not necessarily telling) jokes’’

(Peterson & Seligman, 2004, p.530).

According to Suls (1972), humor can be divided into two groups, looking at cognitive processes forming humor. Suls (1972) argue that humor and jokes can be seen as a sort of problem-solving, and the first part of this process is called the perception. The perception is the turn of the joke, between what was expected and what was the real end or the punch line.

The second part includes the response and the interpretation of the turn (Amir, Biederman, Wang, & Xu, 2013).

Humor has grown as a research field in the later decades. In the 1970's the publications almost tripled in number and it has continued to rise ever since (Goldstein & Ruch, 2018). Some of the first studies ever made in the field of humor were in connection to health. They examined how humor can affect us in positive ways e.g. reduce pain and stress, but also strengthen the immune system. After that, the research on humor in connection to physical and mental health has continued, both more general research and its effect on different diseases, for example, coronary heart disease and diabetes (Goldstein & Ruch, 2018).

Laughter is a human social and emotional expression that is a big component of humor (Ruch & Ekman, 2001). Laughter can also be put into positive and negative groups. As with humor, different kinds of laughter have different impacts on the people surrounding us. Warm and genuine smiles and laughter can be seen as positive and may favor social bonds and relationships while negative laughter is e.g. mocking laughter. Mocking laughter can be used to make fun of other people or to make them feel uncomfortable (Wu et al., 2016). Humor includes an unexpected turn, which is when a sentence changes to a new perspective and makes one burst into a laugh or a smile (Amir et al., 2013).

Both humor and laughter are built up from the individuals' expectations and when the joke takes an unexpected turn, it changes the outlook the person earlier built up on the situation and may make it funny (Martin et al., 2003).

Humor may not always be built on a joke that is meant to be funny from the beginning but can come from a comment or a sound, that was not meant to be funny but can turn into something humorous in a second (Nakamura et al., 2018).

## 2.2. The four Humor Styles

Older studies within the field of humor research have mostly focused on positive forms of humor (Martin & Lefcourt, 1983; Thorson, Powell, Sarmany-Schuller, & Hampes, 1997). Humor is most often described as a positive feature that is a benign and playful type of socialization (Chan et al., 2018). Martin et al. (2003) wrote an article based on the hypothesis that different types of humor can affect us and the people around us in both positive and negative ways. They believed that all humor may not be beneficial to our well-being as earlier thought, but some types of humor may be harmful in different ways (Martin et al., 2003). From this new hypothesis, Martin et al. (2003) built a 2x2 model to separate the different types of humor (See Figure 1). The categorization is based on how the humor is being used, either to enhance and raise oneself (toward self) or to enhance the relationship with other people (toward others) (Martin et al., 2003; Wu et al., 2018), and thereby which target it is built for (Chan et al., 2018). Humor that is being used to enhance oneself can, among other things, be used as a way of coping with stressful situations or as a sort of defense mechanism. Humor that is being used to enhance ones' relationship with others can be used as a way of connecting bonds between people or e.g. to reduce conflicts by making jokes about the situation (Martin et al., 2003). The second part that goes across this section is separated depending on if the humor is relatively kind and benign (kind-hearted) or if it can be seen as harmful and detrimental (unkind/hurtful) (Martin et al., 2003; Wu et al., 2018), and thereby what motivation one has with the joke (Chan et al., 2018).

<b>2x2 Conceptualization</b>	<b>Interpersonal</b> (To enhance ones' relationship with others)	<b>Intrapsychic</b> (To enhance the self)
<b>Conductive to Well-Being</b>	Affiliative Humor	Self-enhancing Humor
<b>Deleterious to Well-Being</b>	Aggressive Humor	Self-defeating Humor

**Figure 1.** *The 2x2 model separating the four humor styles based on Martin et al. (2003).*

What motivation one has with the humor that is being used, has become a bigger focus-direction in the research of humor in the last years. This includes what role one takes in social interactions with other people (Chan et al., 2018). If we shall be able to understand and evaluate the impact on peoples' well-being, it has to be taken into consideration if we are talking about the more benign types of humor or the more detrimental. As important as it is that the so-called "healthy humor" is present within an individual, the "unhealthy humor" should be as absent as possible (Martin et al., 2003). What type of humor one uses has a strong connection with ones' awareness of other peoples' feelings and emotions as well as ones' own. This part of humor can be connected to self-evaluation – What will happen if I tell this joke (Wu et al., 2018)? Based on the 2x2 model of humor, Martin et al. (2003) concluded four different types of humor built from the two dimensions above. These are affiliative humor, self-enhancing humor, aggressive humor, and self-defeating humor (Martin et al., 2003). Affiliative and self-enhancing humor are positive humor styles that can make oneself or other people feel good, while aggressive and self-defeating humor are negative humor styles and can hurt or make oneself or other people feel bad (Ford, Lappi, & Holden, 2016).

**2.2.1. Affiliative humor.** Affiliative humor is a positive humor style that is used to enhance ones' relationship with other people and at the same time reduce ones' tensions and

is mostly kind to oneself (Fox, Hunter, & Jones, 2016). The line between affiliative and aggressive humor can be hard to draw because affiliative humor can involve some playful teasing of other people, even though it is much more harmless than aggressive humor (Martin et al., 2003). People who have affiliative humor as a base are often spontaneous people who also do not take themselves too seriously. They can often tell jokes about themselves without passing the line of what can be detrimental (Martin et al., 2003). As a summary, people that have much of the affiliative humor style, can easily tell jokes, say funny things and amuse other people with their humor to build relationships, without being harmful to themselves (Lefcourt, 2001).

Both affiliative and self-enhancing humor has the ability to strengthen bonds between people and within groups (Chan et al., 2018). These two humor styles are also the ones that have been found to be positively connected with happiness and psychological well-being, while self-defeating humor is negatively related to well-being (Ford et al., 2016).

**2.2.2. Self-enhancing humor.** Self-enhancing humor is the second positive humor style that is being used to enhance the self but at the same time is not detrimental to ones' relationship with other people and do not harm others. It is a sort of coping humor that can be used in a stressful situation where the humor helps to maintain a calm and humorous perspective (Fox et al., 2016). People who have self-enhancing humor as a base can use it as a sort of healthy defense mechanism and tend to have a general humorous view of life. Self-enhancing humor is a good way of dealing with and regulating ones' negative emotions while keeping a humorous outlook on the situation (Li, Li, Pan, Qiu, & Zhang, 2018). Martin et al. (2003) believed self-enhancing humor to have a positive connection with psychological well-being such as self-esteem, and a negative relation with negative emotions such as anxiety. Because of the main point of self-enhancing humor, that it can be used as a healthy defense mechanism while at the same time keeping a realistic perspective, it can be connected to the

Freudian definition of humor. The Freudian definition of humor consists of the thesis that humor is a healthy defense mechanism that helps one, while maintaining a realistic outlook on the situation, to deal with hard situations (Martin et al., 2003). People who are using self-enhancing humor can often be described as individuals who are related with a good psychological state because self-enhancing humor is positively correlated with agreeableness, extraversion, openness, and empathy while it is negatively correlated with neuroticism (Martin et al., 2003; Hampes, 2010; Wu et al., 2018).

It has been found that both affiliative and self-enhancing humor have a negative correlation with depression, anxiety, and suicidal thoughts while they have a positive correlation with both life-satisfaction and self-esteem (Fox et al., 2016).

**2.2.3. Aggressive humor.** Aggressive humor is one of the more negative humor styles that is being used to enhance the self at the expense of other peoples' feelings and emotions. In the long term, it can, of course, be detrimental even to oneself but at the time the joke is being made, it is used to enhance oneself. An example of this kind of situation can be when someone makes a mistake and another person makes fun of it to make oneself look better (Fox et al., 2016). People that have much of the aggressive humor style tend to use humor without taking into consideration how it affects other people e.g. when using racist humor. People with this humor style as their base, cannot often resist impulses to say funny things even if it may hurt other peoples' feelings (Martin et al., 2003). Martin et al. (2003) believed that aggressive humor, as opposed to self-enhancing humor, has a negative relation to well-being and positive relation to negative emotions. As a summary, aggressive humor is related to things like teasing on a higher level, sarcasm, and so-called "put-down" humor. Beyond that, it can also be used as a way to manipulate other people or even threatening them while smiling (Janes & Olson, 2000).

While affiliative and self-defeating humor can build stronger bonds between people, aggressive humor can harm or even break those bonds because of how it can affect other peoples' feelings (Chan et al., 2018).

**2.2.4. Self-defeating humor.** Self-defeating humor is the second negative humor style and it is being used to enhance ones' relationship with other people but is made to the cost of oneself. An example of this type of humor can be when one makes a mistake and the person himself tells everybody how stupid he is. It may make other people laugh but may at the same time harm one's self-esteem. This humor style is the least mentioned one in earlier studies (Fox et al., 2016). People who have self-defeating humor as a base tend to use humor as a way of suppressing and hiding negative feelings. It can also be used as a way to avoid other problems in life (Martin et al., 2003). People who have much of the self-defeating humor tend to often be described as the "class-clown" which often has underlying references to low self-esteem and being attention-seeking (Martin et al., 2003). As a summary, self-defeating humor is when one tries to gain approval or integrate oneself into a group by saying funny things about oneself. It does not always have to be that the person himself tells the joke but can also include laughing along as other people tell mean jokes about himself (Martin et al., 2003).

Self-defeating humor has the opposite correlation with positive and negative emotions in contrast to affiliative and self-enhancing humor. This means that self-defeating humor has a positive correlation with depression, anxiety, and suicidal thoughts while it has a negative correlation with good self-esteem and high life-satisfaction (Fox et al., 2016).

### **3. Humor in the Brain**

According to Suls (1972), the so-called, problem solving of humor can be divided into two phases. The first phase includes the outlook of the absurdity between what was expected by the individual and the actual punch line. The second phase includes how the individual solves the "problem" in the joke and how it is being received. These two phases, along with

e.g. appreciation and understanding of humor, activate different brain areas. Humor has been found to activate different parts of the brain in both hemispheres, though it seems like the hemispheres have different roles in connection to our enjoyment, understanding, and processing of humor. When it comes to the good feeling and genuine laughs that emerge from humor, specific dopamine-based pleasure centers have been found to be activated as well (Goldstein & Ruch, 2018). In recent years, the research on how humor and the different humor styles are built up in the brain has grown, which has, among other things, given a broader understanding of humor processing (Chan, 2016). During this time, the numbers of fMRI studies have grown as well. It has given us a better view of the neural imaging in relation to the appreciation of the different humor styles in the brain (Vrticka et al., 2013b).

According to Vrticka et al. (2013b), personality traits can affect our humor. Preliminary results have shown that emotional stability and experience seeking personality traits within an individual may affect their humor processing. Another study, on children, found preliminary results which indicate that humor can be affected by different personal traits connected to temperament within the child, e.g. shyness and sociability (Vrticka, Black, Neely, Shelly, & Reiss, 2013a). Humor may thereby be affected by individual differences in personal traits and temperament both in children and adults (Vrticka et al., 2013b).

### **3.1. Humor Processing**

Humor consists of a variety of different components including processing, appreciation, comprehension, structure, and content. When looking at the processing of humor, including cognition, laughter, and affect, different brain areas have been found to be activated (Chan et al., 2018). When an individual receives a humorous input and the behavior is being regulated based on that specific information, it has been found to activate the dopaminergic midbrain. The processing of social and emotional input in connection to humor is processed by the prefrontal cortex (PFC), which has been found to be activated both in connection to verbal

benign and detrimental jokes (Chan et al., 2018; Chan, Liao, Tu, & Chen, 2016). According to Goel and Dolan (2001), the most common components of humor can be even more specified to the area ventromedial prefrontal cortex (vmPFC) which is involved in reward processing. Goel and Dolan (2001) also found differences in the brain depending on what type of humor was being processed. When an individual processed a semantic joke (deeper meaning) they found increased activity in the left posterior inferior temporal gyrus, left posterior middle temporal gyrus (MTG), and right posterior MTG, compared to the normal baseline. When individuals instead process puns (more light and easy jokes) Goel and Dolan (2001) found increased activity in the left inferior frontal gyrus (IFG) and left posterior inferior temporal gyrus, compared to the normal baseline.

Verbal jokes can be divided into three phases. The first phase consists of the identification of the jokes incongruities and absurdity, which is processed in the right medial frontal gyrus (MFG), and right MTG. The second phase consists of the processing and evaluation of the jokes incongruities, which is processed in the left superior frontal gyrus (SFG), left inferior parietal lobule (IPL), and IFG. The last phase consists of the appreciation and response to the joke, which is processed in left vmPFC, bilateral parahippocampal gyri, and subcortical bilateral amygdala (Chan et al., 2012; Chan & Lavalley, 2015; Wu et al., 2018).

### **3.2. Humor Appreciation**

Humor appreciation involves one's explanation of the humorous input based on earlier experiences, which have been found to activate a large set of neural structures in both hemispheres. Thus, it has been shown that the right frontal lobe is a major brain area involved in humor appreciation (Lyons & Fitzgerald, 2004; Vrticka et al., 2013b). When investigating which brain areas are connected with humor appreciation, it has been found that the mesolimbic dopaminergic reward systems for humor are one of these neural structures, which

includes activation in the amygdala, midbrain and nucleus accumbens (NAc) (Chan et al., 2018; Wu et al., 2018). The IFG, inferior parietal lobe, insula, vmPFC, and parahippocampal gyrus (PHG) are also some of these structures involved in humor appreciation, though they are mostly connected to the feeling of amusement (Goel & Dolan, 2001; Chan et al., 2012; Chan & Lavalley, 2015). The same study also found a connection between the amusement of a joke and increased activation in the MTG, orbitofrontal cortex (OFC), and the mesocortical system (MCL) in the temporoparietal junction (TPJ) (Chan et al., 2018).

According to earlier studies, lesions in different areas of the brain can affect our processing and appreciation of humorous information (Gardner, Ling, Flamm, & Silverman, 1975). Patients with damage to only the right hemisphere, especially the right frontal lobe, have trouble understanding the meaning and punch line of a joke but can still recognize when a joke is being told especially in verbal humor (Gardner et al., 1975; Wapner, Hamby, & Gardner, 1981; Lyons & Fitzgerald, 2004).

### **3.3. Humor Comprehension**

Humor comprehension is the resolution phase made from a humorous input (the incongruity). This mechanism has been found to decrease when people are in bad moods, suffering from social anxiety, or have major depression (Samson, Lackner, Weiss, & Papousek, 2012).

In one study by Chan et al. (2013), they tried to separate the neural structures involved in incongruity detection and resolution with an event-related fMRI study incorporating unfunny, meaningless, and funny stories. They found that independent of the nature of the stimulus: verbal, visual, or auditory, the specific brain areas involved in the whole process of humor comprehension includes activation in the dorsal anterior cingulate cortex (ACC), precuneus (PREC), posterior cingulate cortex (PCC), medial prefrontal cortex (mPFC),

superior temporal sulcus (STS), temporal pole (TP), left IFG, and the superior temporal gyrus (STG) (Neely, Walter, Black, & Reiss, 2012; Vrticka et al., 2013b).

### **3.4. Processing and Appreciation of different Joke Types**

In the research of humor and its neural correlates, Chan and Lavalley (2015) examined if they also could find any neural differences between different joke types. The three joke types investigated in this study are bridging-inference jokes (BJs), exaggeration jokes (EJs), and ambiguity jokes (AJs). BJs are jokes where the key point is not clearly stated in the sentence, but the listener has to think it through to understand the meaning of the joke. EJs are jokes where the key point is much smaller or bigger than expected and by that, creates an absurdity, and AJs are jokes that have a double meaning (Chan, 2016; Chan & Lavalley, 2015). The results showed a significantly increased activity in the TPJ and MTG during the processing of BJs, and a significantly increased activity in the OFC in response to the appreciation of this type of jokes. The results also showed a significantly increased activity in the IPL and IFG during the processing of both EJs and AJs, and a significantly increased activity was shown in the amygdala during appreciation of EJs, while AJs was associated with a significantly increased activity in the PHG (Chan & Lavalley, 2015; Chan, 2016).

## **4. The four Humor Styles in the Brain**

When taking a deeper look into how and if the four humor styles are, in some ways, processed in different parts of the brain or not, we can start by taking a look at how they are connected to other areas of life. It seems that the affiliative and self-enhancing humor styles are related to happiness. Happier people tend to use more of these humor styles rather than aggressive and self-defeating humor, which are negatively related to happiness. Because happiness is affected by different parts of the brain, it may be that these areas are related to affiliative and self-enhancing humor as well (Ford et al., 2016). According to Myers and Diener (1995), a persons' happiness is based on four components of personality traits

including locus of control, self-esteem, extraversion, and optimism. Those humor styles that have been found to have the strongest relation to happiness in either positive or negative ways is the self-directed humor styles. One can predict a persons' well-being by measuring to which degree self-enhancing and self-defeating humor is being used by that person (Cann, Stilwell, & Taku, 2010).

#### **4.1. Humor Styles Relation to White Matter**

In a study by Wu et al. (2018), white matter structure was examined in relation to effect on different humor styles. The scholars' hypothesis was built on earlier findings of how the four humor styles and personality traits have a significant correlation with white matter structure in the brain (Martin et al., 2003; Liu, 2012). These measurements have been made in relation to the big-five personality traits: openness, conscientiousness, extraversion, agreeableness, and neuroticism (Judge, Higgins, Thoresen, & Barrick, 1999). According to Bjørnebekk et al. (2013) more positive personality traits: openness, extraversion, agreeableness, and theory of mind does have a positive correlation with white matter structures in the brain, while neuroticism has a negative correlation with white matter structure. Xu and Potenza (2012) have also found a correlation between white matter structure and aggressive behaviors. Greengross et al. (2011) did a study to try to connect the four humor styles with the big-five personality traits. People who mostly used affiliative humor was found to also have higher levels of conscientiousness. People with more self-enhancing humor did show lower levels of neuroticism. Both of these more positive humor styles were found to have a strong relation to openness, extraversion, and agreeableness, and self-esteem. The use of aggressive humor was found to have a negative relation with openness and agreeableness, while self-defeating humor had a positive relation to openness. People who tend to use the two more negative humor styles were found to have higher levels of neuroticism and lower levels of conscientiousness (Greengross et al., 2011).

Wu et al. (2018), used the DTI technique to measure white matter structures in the brain in relation to the four humor styles. In the same study, they found significant correlations for each of the four humor styles in connection to different areas in the brain. Affiliative humor was found to have a positive correlation with the left STG ( $p = 0.003$ ), while self-enhancing humor is positively correlated with the left IFG ( $p < 0.001$ ) and posterior cingulate gyrus (PCG) ( $p = 0.001$ ). Aggressive humor has a negative correlation with the left STG ( $p < 0.001$ ), while self-defeating humor is positively correlated with the right cingulate gyrus ( $p < 0.001$ ). From these results, Wu et al. (2018) found that self-enhancing humor has a positive relationship with white matter structure, and aggressive humor has a negative relationship to white matter structure in the brain.

#### **4.2. Humor Styles Relation to Brain Areas**

The activity in the brain associated with the different humor styles is widely spread and barely overlaps, thus it seems that each humor style is influenced by different brain regions (Wu et al., 2018). Affiliative humor has been found to have a relation with a variety of personality traits, there among openness (Wu et al., 2018). Self-enhancing humor showed a positive relation with left IFG and PCG which strengthens the thesis about how self-enhancing humor is related to a variety of personality traits since positive personality traits such as empathy, emotion recognition, and self-awareness, are correlated with activity in these, or closely placed, areas of the brain as well. E.g. empathy is correlated with activity in both the IFG and PCG (Wu et al., 2018). Aggressive humor was negatively correlated with activity in the left STG. This supports the thesis about how aggressive humor is negatively correlated with openness according to Wu et al. (2018) since openness is positively correlated with activity in the STG (Kitamura et al., 2016). Self-defeating humor is positively correlated with activity in the right cingulate gyrus, which is also correlated with self-awareness (Wu et al., 2018). The efficiency of regional white matter communication may predict humor styles since

it has a positive correlation with self-enhancing humor while having a negative correlation with aggressive humor (Wu et al., 2018).

Humor can be divided into different groups depending on how it is being expressed or received. These groups include laughter, affect, or cognition (Chan, 2016; Chan et al., 2018). According to a study by Chan et al. (2016) examining humor motivation, verbal humor differs in which brain areas are active depending on if it is a kind and benign humor style or if it is a harmful and detrimental humor style. The benign humor styles (affiliative or self-enhancing humor), have been found to be connected to increased activation in the NAc and the midbrain. While the detrimental humor styles (aggressive or self-defeating humor) have been found to be connected to increased activation in the midbrain as well, but also in the dorsomedial prefrontal cortex (dmPFC) (Chan et al., 2016). In a later fMRI study made by Chan et al. (2018), they found no significant activation of any specific brain areas during the appreciation of the detrimental humor styles, but they found significant activation of the right TPJ during the appreciation of the benign humor styles. In the same study, they found a difference in if the humor was self-directed (self-enhancing or self-defeating humor) or other-directed (affiliative or aggressive humor). The appreciation of other-directed humor styles had a significant relation to the activation of the left NAc and right midbrain. These areas were not as active during the appreciation of the self-directed humor styles, and no other brain areas had a significant relation with the self-directed humor styles (Chan et al., 2018).

According to Chan et al. (2018), the neural structures related to benign humor has a greater relation to affiliative humor than to self-enhancing humor. These structures include the right NAc, right midbrain, right vmPFC, left MTG, left TP, and left TPJ. Detrimental humor showed a significant relation to two more areas beyond those mentioned earlier. These areas are the left amygdala and the right subgenual ACC (sgACC), though these areas had a stronger relation to self-defeating humor than to aggressive humor (Chan et al., 2018).

Appreciation of self-directed humor has been found to be related to some specific brain areas, though self-defeating humor was found to have a stronger relation to these areas than self-enhancing humor do. These areas include the left TP, bilateral midbrain, and right NAc (Chan et al., 2018). Other-directed humor was found to be related to four other brain areas, though affiliative humor was found to have a stronger relation to these areas than what aggressive humor does. These areas are the right sgACC, right NAc, right TPJ, and right medial OFC (mOFC) (Chan et al., 2018).

### **4.3 Bright and Dark Types of Humor**

In another study, Papousek et al. (2017) examined how bright and dark types of humor are built up in the brain. Papousek et al. (2017) did not base their study on the work by Martin et al. (2003) which is the basis for this review. Instead, they divide humor into eight different types. Dark humor types are described as ‘‘laughing-at’’ humor and includes cynicism, sarcasm, and irony. Bright humor types are described as ‘‘laughing-with’’ humor and only include benign humor. The remaining four humor types are placed outside of these groups and consist of fun, nonsense, wit, and satire humor (Papousek et al., 2017). This kind of humor categorization focuses more on the production and use of humor rather than the appreciation and processing (Papousek et al., 2017). According to Papousek et al. (2013) the PFC, and especially the prefrontal-posterior coupling, affects how people perceive different emotional signals. When the perceptual ‘‘gates’’ in this area open, because of the loosening of control in the PFC, the brain is more easily affected by the socio-emotional signals. When the brain experiences something aversive, the coupling of the prefrontal-posterior areas strengthens, and the perceptual gate becomes more closed. This is made to protect the individual to not be as affected by the more unlikeable or disturbing input (Papousek et al., 2013; Reiser et al., 2012). The purpose of the study by Papousek et al. (2017) was to investigate how bright and dark humor is connected with activity in the prefrontal-posterior

coupling by measuring the EEG-activity while participants were watching people laughing or crying. They found that a decreased prefrontal-posterior coupling when watching a crying stimulus had a positive correlation with the use of dark (laughing-at) humor but had no correlation with bright (laughing-with) humor. Bright humor was positively correlated with decreased prefrontal-posterior coupling during the laughing stimulus, which was not observed for dark humor (Papousek et al., 2017). Papousek et al. (2017) concluded that our use of different humor styles, either bright or dark, is dependent on the prefrontal-posterior coupling and the automatic response of these brain mechanisms, on the socio-emotional information that is being received.

## **5. Discussion**

### **5.1. Humor**

Humor is a broad term and includes many different factors. Thereby, it is hard to give an exact definition, both the general expression of it and in terms of the neural components (Martin, 2010).

Humor is often referred to as positive, but it can also generate negative feelings and emotions both in oneself and other people. It is described as an important socio-emotional bonding technique, and even if laughter and smiling have been seen in other primates, it is mostly referred to as a human-specific character trait (Vrticka et al., 2013b). In this sentence, we often tend to describe humor as a sort of play, though it can be used as a coping technique or a defense mechanism as well.

The aim of this thesis was to define how the four humor styles are connected to activity in different brain areas. In other words, to examine the neural activity related with the appreciation for each humor style. To be able to do this, a general overview of the neural connections in relation to overall humor had to be established. To summarize the connections that have been found through this review, we can see that some brain areas are active during

all three factors of humor: processing, appreciation, and comprehension (Chan et al., 2018). These brain areas are the PFC (ventromedial and medial) and IFG (left and bilateral). Another brain area that was found to be active during both humor processing and appreciation is the midbrain (Chan et al., 2018; Goel & Dolan, 2001; Neely et al., 2012; Vrticka et al., 2013b; Wu et al., 2018). Looking at the four humor styles, many different brain areas are active in relation to them, though it has been found that the midbrain, NAc, and the PFC is active in relation to all four humor styles. Affiliative and self-enhancing humor share activity in most cases the same brain areas, whereas self-enhancing and aggressive humor to lesser extent share activity in related brain areas.

As mentioned earlier, the PFC and IFG were active during all three factors of humor: including processing, appreciation and comprehension, and the midbrain was found active both during humor processing and appreciation. The PFC is thought to be connected to so-called "higher" brain functions and is an important part of the executive functions which includes, among other things, judgmental thinking, planning, and reasoning. It is also referred to as an important part of our emotional and social system, which influences our personality (Miller & Cohen, 2001). Looking at the other functions of the PFC, it is not hard to understand why it is such an important area for humor as well, since humor includes planning, reasoning, and is a form of emotion. Azim, Mobbs, Jo, Menon, and Reiss (2005) believe that the connection between the PFC and humor is due to its functioning of balancing and responding to the humorous input of information. The IFG is, as well as the PFC, placed in the frontal lobe and has also been found to be connected to higher brain functions, such as emotional empathy (Shamay-Tsoory, Aharon-Peretz, & Perry, 2009). The IFG partly includes Broca's area which is an important area for language processing and comprehension, both in sign and speech (Fadiga, Craighero, & D'Ausilio, 2009). To be able to understand humor, one has to understand the language regardless of if the joke depends on verbal or body language,

which Azim et al. (2005) also believe is important for the decoding of the humorous input. In some part, empathy can be important in expressing and processing humor. If one has empathy, it may not be funny to see someone fall. The midbrain is an important brain area for the movement of our body and eyes, though it is also sufficient for visual and auditory processing, and for modulating our behavior (Limbrick-Oldfield et al., 2012). To summarize, we can see that humor processing, appreciation, and comprehension all seem to be related to higher cognitive functions, such as emotional, social and behavioral balance, planning and reasoning, empathy and language, and visual and auditory processing.

## **5.2. Neural Relations of the Humor Styles**

The four humor styles seem to be related to the brain areas found to be active during general humor in different ways. Some studies have examined how the four humor styles are processed in the brain by dividing the research based on if it is benign or detrimental, directed to the self or others, and not according to the specific humor styles directly (Chan et al., 2018). The PFC and midbrain are activated during all humor styles, both during the benign (affiliative and self-enhancing humor) and detrimental (aggressive and self-defeating humor) humor styles. However, upon closer examination, different parts of the PFC are more (or less) active in response to the different humor styles. The vmPFC is more active during benign humor (Chan et al., 2018). The vmPFC has also been found to be more active in connection to the functions of reward processing (Bzdok et al., 2013). The dmPFC is more active during detrimental humor (Chan et al., 2018), which has also been found to be more active in relation to the functions of perspective-taking and episodic memory (Bzdok et al., 2013). It may be that the vmPFC is more active during the benign humor styles because it includes reward processing due to the positive emotions involved in these humor styles, which may not be used as much in connection to the detrimental humor styles. The dmPFC may be more active during the detrimental humor styles because during detrimental humor one may tend to think

more about how the humor affects other people in the way one wants it to do. As mentioned earlier, aggressive humor can be referred to as put-down humor of other people in order to build up oneself (Chan et al., 2018). It may be that one uses perspective-taking to reason about how to keep the hierarchies order in connection to the use of humor.

When looking at the differences between self-directed (self-enhancing and self-defeating) and other-directed humor (affiliative and aggressive) and which brain areas are more active during these humor styles, studies found that the NAc and midbrain were highly active during all of them (Chan et al., 2018). The relation between activity in the midbrain, self-directed and other-directed humor can be due to that all humor, benign or detrimental, need to be processed (either visually or auditory), planned and reasoned, and affects our emotions, behavior, and our social bonds. The NAc is a part of the reward system and is also related to the feeling of pleasure (Salamone, Correa, Mingote, & Weber, 2005). It can be assumed that humor brings us, most often, pleasure regardless of if it is directed to the self or other people. Azim et al. (2005) also mention the importance of NAc in reward-related responses to different positive stimuli, such as humor. The relation between the NAc and self-directed humor showed stronger activation in connection to self-defeating humor, more than with self-enhancing humor (Chan et al., 2018). It may be that it brings us more pleasure to see other people laugh even if it is detrimental to oneself. One brain area that is active during the appreciation of self-directed humor but not active during other-directed humor is the TP (Chan et al., 2018). The TP is referred to as an extended part of the limbic system and is thought to be involved in both social and emotional processing which includes face recognition and theory of mind (Olson, Plotzker, & Ezzyat, 2007). The theory of mind is important for the processing and evaluation of humor because it helps one to be able to connect memories and earlier information to what is being mentioned in the present joke. Theory of mind also seems to help increase the perceived funniness in a specific joke (Kohn,

Kellermann, Gur, Schneider, & Habel, 2011). Beyond NAc and midbrain, there are three more areas active during other-directed humor styles, including the sgACC, TPJ, and OFC (Chan et al., 2018). The ACC is involved in higher cognitive functions such as self-regulation, impulse-control, decision-making and morality (Bush, Luu, & Posner, 2000) The specific part of sgACC have also been found to be involved in the experience of sadness (Ramirez-Mahaluf, Perramon, Ota, Villoslada, & Compte, 2018). The TPJ is found to be an important area for the theory of mind and empathy which also includes the reasoning about other peoples' intentions and desires (Samson, Apperly, Chiavarino, & Humphreys, 2004; Decety & Lamm, 2007). The OFC is most often referred to as a critical brain area in connection to decision making (Bechara, Damasio, & Damasio, 2000). Taking all of these parts into consideration, it is easy to understand the connection between them and other-directed humor. When making jokes directed towards other people to make them feel good and laugh along, one needs to consider ethics and morality, as is processed in the ACC. The ACC may also be connected to mentalization, and thereby included in the process of understanding different jokes (Kohn et al., 2011). One also has to be able to think about other peoples' desires and have empathy for their response, which includes decision making, and as Vrticka, Neely, Walter Shelly, Black, and Reiss (2013) mentions, to understand the social factors of humor, which is processed in the TPJ and OFC. These brain areas have been found to have a stronger relationship with affiliative humor than with aggressive humor, which strengthens the thesis that when using benign other-directed (affiliative) humor we may think more about morality and empathy for other people, which may not be as present when using detrimental other-directed (aggressive) humor. When using aggressive humor, it is to make oneself feel good regardless of other peoples' emotions and thoughts about it. Thereby, one may not use empathy or theory of mind as much because it does not matter for them, as it does for those people who use affiliative humor.

**5.2.1. Benign Humor.** It seems like the two more benign humor styles share activity in many of the same brain areas and only differ in some parts, and the same applies to the detrimental humor styles. Benign humor is connected with activity in the NAc, TPJ, TP, and MTG, beyond those mentioned earlier (Chan et al., 2018). The MTG functions are still quite unknown but it is believed to be connected to a pure visual association in both objects and faces and overall auditory and visual processing. MTG has also been found to be connected with the understanding of words meaning while reading (Visser, Jefferies, Embleton, & Lambon Ralph, 2012). We can only speculate on why these areas are more active during benign humor than during detrimental humor. Benign humor includes processing of one's own and other peoples' feelings and emotions which is related to empathy, theory of mind, and social and emotional processing. As mentioned earlier, the PFC, TP, and MTG are active during benign humor, though these areas had a stronger activation during affiliative humor than with self-enhancing humor. The hypothetical connection mentioned above is in line with these findings, since affiliative humor may involve more theory of mind and empathy compared to self-enhancing humor, which is more focused on the subjective feelings even if it does not hurt other people. The MTG is more active during benign humor than detrimental and it may be because when using benign humor, one is being more open to the appreciation and feelings of one's own and other peoples' emotions, which decreases in some part during detrimental humor.

Taking a deeper look in the specific humor styles included in benign humor, studies found that affiliative humor is specifically correlated to the white matter structure in the STG, beyond the other brain areas found to be connected to benign and other-directed humor (Wu et al., 2018). The STG is active during perception of emotions (especially facial stimuli), and auditory and language processing (Bigler et al., 2007). Affiliative humor is a kind and other-directed humor style. It means that, when using this humor style, it is important how the

surroundings respond to the joke and humor, and that nobody gets hurt by it. Thereby, it may be that people who use affiliative humor think more about how they express themselves and pay more attention to other peoples' emotions, than what people who use the other humor styles do. Affiliative humor has been found to be related to other positive character traits, such as empathy, openness, and self-esteem which can be seen in connection to these brain areas as well, thus these character traits have been shown to be connected to much of the same brain areas as affiliative humor (Wu et al., 2018).

The second benign humor style, self-enhancing humor, was found to be related to activity in the IFG and PCG, both in terms of directly measured brain activity and in connection to white matter structure (Wu et al., 2018). It is also related to the other brain areas found to be connected to benign and self-directed humor. Hypothetically, the activation of the IFG during self-enhancing humor can be due to that self-enhancing humor sometimes can be hard to separate from self-defeating humor. It is a fine line between making fun of oneself and being detrimental to oneself. Therefore, one has to be conscious of one's own feelings, as partly processed in the IFG (Shamay-Tsoory et al., 2009). Self-enhancing humor can be used as a coping mechanism in hard situations, and because the IFG is one of the brain areas believed to have a positive influence on self-enhancing humor, the IFG may help lead to better physical and mental health in these people (Wu et al., 2018).

The PCG is found to be involved in both spatial orientation and memory, as well as emotional and behavioral regulation (Vogt, Finch, & Olson, 1992). Both the IFG and PCG can be related to all humor styles, though these areas are more strongly related to self-enhancing humor. Self-enhancing humor is self-directed and a benign humor style, meaning that empathy for feelings of other people is important and so is the ability to regulate one's own emotions and behavior, which is partially processed in the IFG and PCG. For this reason

does self-enhancing humor also affects our physical and mental health in a positive way (Wu et al., 2018).

**5.2.2. Detrimental Humor.** The detrimental humor styles are connected to activity in the amygdala and sgACC, beyond those mentioned earlier. These areas were found to be more active in response to self-defeating humor, than to aggressive humor (Chan et al., 2018). The amygdala is a broad function-area that is, for instance, involved in the processing of decision-making, memory, and emotional responses such as aggression, anxiety, and fear (Davis & Whalen, 2001). The connection between the detrimental humor styles and the sgACC and amygdala may be because these brain areas are involved in the experience of sadness and emotional responses such as aggression. It may be that most people who experience detrimental humor feel negative emotions in some ways, independent on if it is directed to oneself or others.

Taking a deeper look into which brain areas are connected to the specific detrimental humor styles, it has been found that the aggressive humor style has a negative correlation with white matter structure in the STG, which is the opposite to affiliative humor (Wu et al., 2018). The STG is involved in emotional perception and especially facial stimuli. These functions are important when using affiliative humor because it is more dependent on positive responses from the receiver, which is not the case in aggressive humor. When using aggressive humor, it is most often done to try to better oneself by being demeaning of others. Thereby, it might be that aggressive humor has a negative correlation with the STG, thus the outlook of peoples' emotional response is not that important, but instead how the person, telling the joke, feels. While affiliative humor has a positive relation to empathy, aggressive humor has a negative relation to empathy but a positive relation to neuroticism. These findings are suitable to the relation between these humor styles and the STG, thus the STG is positively related to openness (Wu et al., 2018).

The second humor style included in detrimental humor is self-defeating humor, which is connected to activity in the right cingulate gyrus both in terms of directly measured brain activity and in correlation to white matter structure (Wu et al., 2018). The cingulate gyrus is one of the brain areas involved in the processing of pain and emotions (Vogt, 2005). Self-defeating humor is most often detrimental to oneself while making other people laugh at one's own cost. It may be that the connection between self-defeating humor and the cingulate gyrus is due to the focus of the self since it is a self-directed humor style (Wu et al., 2018).

As can be seen, there are some neural differences between the four humor styles, depending on if it is benign or detrimental, directed to oneself or others, and specifically to each humor style. Some brain areas are shared through all humor styles, while some are specified to only one. Figure 2 below depicts an overview of the brain areas involved in the different humor styles.

Figure 2 also shows which humor styles to greater or lesser extent share the same brain areas. The humor styles that are connected to activity in many of the same brain areas are the affiliative humor and self-enhancing humor. These are the two humor styles that are described as benign humor, which makes them much alike even in the execution. The two humor styles that are most unlike each other in connection to the brain areas activity, is the self-enhancing humor and aggressive humor styles, thus they only share the midbrain, NAc, and TP. Self-enhancing humor is positively correlated with white matter structure in the brain, and aggressive humor is negatively correlated with white matter structure. These are some of the humor styles that are most unlike each other in the execution as well because while self-enhancing humor is benign and self-directed, aggressive humor is detrimental and other-directed. The activity in different brain areas seems to confirm the descriptions of the different humor styles as well.

<b>Brain Areas</b>	<b>Affiliative</b>	<b>Self-enhancing</b>	<b>Aggressive</b>	<b>Self-defeating</b>
Midbrain	X	X	X	X
NAc	X	X	X	X
vmPFC	X	X		
dmPFC			X	X
TPJ	X	X	X	
TP	X	X		X
MTG	X	X		
sgACC	X		X	X
OFC	X		X	
STG	X			
IFG		X		
PCG		X		
Cingulate gyrus				X
Amygdala			X	X

**Figure 2.** Model showing different brain areas connection and correlation with the four humor styles.

As can be seen in figure 2, the humor styles connections to activity in the brain are partly separated, the more unlike and different the humor styles are, the more separated they are in the brain as well. Affiliative and self-enhancing humor have both a negative correlation with depression, anxiety, and suicidal thoughts (Fox et al., 2016), though it may be that aggressive and self-defeating humor has a positive correlation to it. These earlier findings in connection to neural connectivity can be helpful. It may be that we, in the future, can help people predict and prevent unwanted behavior and emotions, such as aggression and anxiety, by looking at how individuals use their daily humor.

### **5.3. Ethical and Societal Implications**

The present thesis includes a variety of articles based on research on humans. These studies can have been affected by various confounding variables that may affect how people answer to, e.g. the four humor styles. When examining the use, processing, and appreciation of different humor styles e.g. Chan et al. (2016), it is important to respect peoples' emotions and as with all kinds of scientific research, ethical and societal factors need to be considered. A more detailed outlook of the humor styles and their relation to other personality traits may help to see early signs of mental illness, which may in turn give people the chance to get better instead of falling deeper and may end up in a depression, which in turn, could help save societal money, peoples well-being and happiness.

### **5.4. Limitations and Future Research**

In the present thesis, the author has tried to find and include articles that are the most relevant to answer the questions of how humor and the four humor styles are connected in the brain. The author has also tried to mix older studies with high citation-rate, with newer and more recent findings. Thought, it may be that some articles and studies have been missed and can be added to the thesis.

When looking at what is missing in earlier research or needs to be studied more, there are a variety of things that could need a closer look in connection to all fields mentioned above. According to Wu et al. (2018), many studies have examined how humor processing is connected to neural structures, but few studies have examined which neural structures are active during the use of humor. Thereby, there are more answers of how people process humor and which of the humor styles people appreciate to hear or read, but not very much research on why an individual choose to use a specific humor style himself. It may be that the brain areas found to be active during humor processing or appreciation have an overlapping effect on the use of humor, which may also include humor production from the individual

himself, though this can only be speculated. Thereby, more research on the neural connections of the use and production of humor has to be done, to get clearer answers to which brain areas are involved in humor, overall and in connection to the humor styles. Amir et al. (2013), discussed that other confounding variables can affect the activity of different brain areas when watching funny video clips. Some brain areas that are connected to humor, is a part of the reward system e.g. NAc. Amir et al. (2013) mention that the connection between some parts in the reward system and humor can be due to e.g. seeing something beautiful or something else that they like in the video and is not necessarily based on the humor alone. Confounding variables are always going to be present, thereby, more studies have to be made to try to control these variables and get as many matching results as possible.

The author speculate on if some more overlapping studies would be made on humor as a whole, combining all the different factors of humor, including production. Most of the studies that have been included in this thesis have focused on one part, either processing, appreciating, or humor comprehension. If one study would use a big group of people to study all these factors, including the use of humor, it would give a whole overview of how humor and the different humor styles are connected in the brain. Maybe this would give answers to if, in general, we use the same humor style ourselves, that we appreciate in others.

No neural studies in relation to cultural differences in humor have been made yet. Neither have any studies been made regarding gender differences in relation to the four humor styles. The author believes that we could be able to examine these questions in bigger forms. If we are able to get a clearer picture of how people differ in their use and appreciation of humor, partly dependent on their culture and gender it may help to prevent mental illness even more.

## 5.5. Conclusion

The aim of this thesis was to examine how humor and the four humor styles, as defined by Martin et al. (2003), is connected in the brain. Including, how the humor styles are separated or overlap in relation to activity in some brain areas.

The conclusion of how humor and the humor styles are connected in the brain is that the PFC and IFG are active during all three factors of humor being examined, including humor processing, appreciation, and comprehension. The midbrain and NAc are the brain areas found to be active during all four humor styles. The PFC is also active during all four humor styles, though the vmPFC is active during the benign humor styles, while the dmPFC is active during the detrimental humor styles. Activation of the other brain areas are divided between the different humor styles. The benign humor styles (affiliate and self-enhancing humor), that are much alike share activation in more of the same brain areas, more than those humor styles (e.g. self-enhancing and aggressive humor) that are very much unlike each other. It means that we can, in bigger parts, separate the different humor styles in relation to the brain dependent on if they are self-directed or other-directed, benign or detrimental. This means that we have an answer to the main question of this thesis. The four humor styles are more separated in the brain the more diverse they are, while they share activity in more brain areas the more similar they are.

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