Cerebral Asymmetries, Motivation, and Cognitive Processing: An Analysis of Individual Differences

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Abstract

Everyday life experience tells us that individual differences apparently matter. Although confronted with the same situation, individuals seem to act and react in different ways. On a behavioral and self-report level, individual differences are well documented. Over the past decades, they have been systematically assessed and embedded in complex theories of personality. On the other hand, the influence of personality differences on cognitive processes and their cerebral substrate is far from being entirely understood. Especially the complex interplay of two or more aspects, like individual differences (e.g., in motivational processes), cognitive functions (e.g., intuition), cerebral activation and lateralization, and humoral processes (e.g., cortisol), are seldom aim of psychological research.

The Personality Systems Interaction (PSI) theory (Kuhl, 2000, 2001) provides a theoretical framework, which tries to incorporate the above-mentioned aspects. On the background of PSI theory, the aim of the present work was to investigate differences in motivational processing and how they are related to hemispherical asymmetries, cognitive processing, and humoral reactivity. Each of the three research articles presented throughout the present work tackles different aspects of this general research question. For this, a variety of different methodological techniques were used (e.g., questionnaires, implicit measures, electroencephalography, etc.) to approach the aforementioned goal.

The first research paper presented in the current work examines the relationship between the implicit affiliation motive and intuition, as a form cognitive processing. Previous research already demonstrated that affiliation-laden primes facilitate intuitive thought (Kuhl & Kazén, 2008). Therefore, it could be expected that trait affiliation motive would also be correlated with intuition. Intuition in turn is thought to be a function of right hemispheric processes. An association between trait affiliation and intuition could therefore indirectly indicate a lateralization to the right side for affiliation. With the first study of the present work, the author tested this association. Thirty-nine students filled in the Operant Motive Test for the assessment of implicit affiliation, a variant of the Thematic Apperception Test. Then, 9 months later, participants engaged in a Remote Associates Test in which they intuitively had to indicate whether three words are semantically related. As expected, the implicit affiliation motive significantly predicted the accuracy of identifying related word triads. No other implicit or explicit measure, nor state or trait positive affect was associated with intuition.

With the second research article, the aforementioned indirect association between affiliation and lateralized processing was investigated more directly. Previous research on relationships between personality and EEG resting state frontal asymmetries mainly focused on individual differences with respect to motivational direction (i.e., approach vs. withdrawal). By contrast, the second article investigated frontal asymmetries as a function of individual differences in implicit affiliation motive. The goal was not only to contribute to the validation of PSI theory and to the investigation of the laterality of the affiliation motive, but also to disentangle the contribution of different social motives to frontal EEG asymmetries. The consideration of social motives, such as the affiliation motive, seemed to be necessary, because a recent meta-analysis showed that the association between approach motivation and frontal asymmetries is negligible or that unidentified moderators drive this association. From previous research and the results from the first paper presented in the current work, an association between affiliation motive and right frontal activity was predicted. Additionally, to control for possible associations with motivational direction, trait behavioral inhibition, behavioral activation, and anger were assessed and correlated with frontal asymmetries. Seventy-two right-handed students were tested. As expected and in accordance with the findings from the first paper, the author found that relative right frontal activity (indicated by low alpha frequency power) was associated with the affiliation motive. To explore brain regions responsible for this association at scalp sites, a source localization algorithm was applied. Intracranial distribution of primary current densities for the alpha band spectrum in source space was estimated and correlated with implicit affiliation scores. A significantly correlating area could be identified in the right ventromedial prefrontal cortex (Brodmann Area 10). No other associations at scalp sites or in source space could be found for motivational direction.

The third research article presented in the current work highlights motivational differences slightly different from those presented above. It deals with dynamic motivational processes, such as action orientation, and how they moderate the association between cerebral asymmetries and the physiological stress reaction. Hypothalamus pituitary adrenocortical (HPA) system activity and frontal brain asymmetries have both been linked to stress and emotion but their relationship remains unclear, especially when additionally considering individual differences. Therefore, participants were exposed to public speaking stress while salivary cortisol levels (as a marker of HPA activity) and resting frontal EEG alpha asymmetries were assessed before and after stress induction. The results indicate that higher post stressor cortisol levels were associated with higher relative left frontal activity. State oriented participants showed a stronger association between cortisol response and left frontal activity than action oriented participants.

The above-mentioned findings are discussed referring to PSI theory and their possible implications. Additionally, shortcomings of the present research and possible remedies will be presented.

Publications

Publications for the cumulative dissertation:

Chapter 2 published as: Quirin, M., Düsing, R., & Kuhl, J. (2013). Implicit affiliation motive predicts correct intuitive judgment. *Journal of Individual Differences, 34*(1), 24-31.

Chapter 3 published as: Quirin, M., Gruber, T., Kuhl, J., & Düsing, R. (2013). Is love right? Prefrontal resting brain asymmetry is related to the affiliation motive. *Frontiers in human neuroscience, 7*.

Chapter 4 submitted for publication: Düsing, R., Kuhl, J., Tops, M., Koole, S. L., & Quirin, M. (under review). Emotion Regulation Abilities Moderate the Relationship Between Left Frontal Brain Activity and Cortisol Release After Social Stress.

Your vision will become clear only when you look into your heart.
Who looks outside, dreams. Who looks inside, awakens.

Carl Gustav Jung

Chapter 1

A Brief History of Research in Hemisphere Laterality

The story of research into hemispherical differences of the human brain goes back to the fundamental assumption that specific anatomical structures in the human brain can be linked to different mental functions. Already back in the late eighteenth century Franz Joseph Gall, a neuroanatomist and father of phrenology, tried to ascribe different traits, emotions, and thoughts to specific brain areas. Although the basic idea of phrenology, inferring underlying brain structures and therefore corresponding mental abilities from skull sizes, has been proven wrong, the assumption of a modular structure of the brain and hence a possible localizability of mental functions can be considered as a cornerstone of modern neuropsychology.

At first glance, on a macro-scale the two hemispheres seem not to differ from each anatomically, but already on this level distinct features can be identified. The hemispheres differ with regard to neuroanatomy, neurochemistry, and function (for an overview, see Banich, 1997). For example, the right *frontal* lobe extends farther and wider towards the skull, whereas the left *occipital* lobe extends farther and wider towards the skull (Galaburda, LeMay, Kemper, & Geschwind, 1978). The sylvian fissure extends more to the left horizontally and more upward on the right side (Hochberg & le May, 1975; Rubens, Mahowald, & Hutton, 1976). In about 65% of all human brains, the planum temporale is usually up to ten times larger in the left hemisphere as in the right hemisphere (Geschwind & Levitsky, 1968) and has been related to the lateralization of language processing (Foundas, Leonard, Gilmore, Fennell, & Heilman, 1994), although participants with a strong asymmetry do not necessarily show a functional difference (e.g. Dos Santos Sequeira et al., 2006; Eckert, Leonard, Possing, & Binder, 2006). Additionally, the frontal opercular area in the left hemisphere, which is imported for the speech output, exhibited greater branching of dendrites in the left as compared to the right hemisphere (Falzi, Perrone, & Vignolo, 1982; Scheibel, 1984). Recent findings suggest that cerebral asymmetries develop at a very early stage already in the embryo and are the result of differential gene expressions (Sun et al., 2005).

The assumption of hemispheric *functional* specialization and laterality has often been criticized or presented in an oversimplified way (e.g. Efron, 1990). But a different functioning of the two hemispheres can not be denied, as it is beyond dispute for the anterior-posterior or the dorsal-ventral dimension. Already Paul Broca, a french neurologist, provided evidence for a lateralization of language processing in the middle of the 19th century, which are well in line with above mentioned findings reporting a greater branching in the frontal opercular area. About 100 years later, Sperry (1964) showed that animals and human patients are grossly undisturbed in typical brain processes, after bisecting through the corpus collosum. But this so called *split-brain patients* showed a deviant behavior when objects were presented to the left or right visual hemifield. When an object was only presented to the left hemifield, i.e. perceptual processing takes place in the right cerebral hemisphere, patients were not able to name the objects, but to identify them by feeling and touching.

It seems as if both hemispheres are able to take over functions of opposed one and that specialization for specific functions emerges during maturation (Kolb & Whishaw, 1993). More specifically, the left hemisphere seems to be organized in a more modular manner, whereas the right hemisphere works less modular and more global (Scheibel et al., 1985). Today, hemispherical asymmetries are reported in different psychological areas and are also the basis of psychological theorizing (e.g. approach versus avoidance motivation, see Davidson, 1992a; Harmon-Jones, Gable, & Peterson, 2010; for an integrative review, see Tops, Boksem, Luu, & Tucker, 2010). The basis for the present work is the **Personality Systems Interactions** (**PSI**) theory (Kuhl, 2000, 2001).

Typically, lateralized cerebral processing and lateralization are examined without considering individual differences. When cerebral asymmetries emerge at a very early stage of the ontogenetic development (e.g. Sun et al., 2005), it may be assumed that they also contribute to individual differences in personality and motivational processes. The PSI framework accounts for this very early (i.e. genetic) differences as well as differences, which are more likely to develop by socialization. A key feature of PSI theory is the description of the interaction of these *structural* and *dynamic* parameters, respectively. In this notion, personality is not constituted by the arousability of one specific system or area, but by the dynamic exchange and interplay of different systems.

To put it differently, within the PSI theory different functional levels and systems of personality functioning are assumed. Each of these levels can be described in terms of antagonistic, interconnected subsystems, which in turn are related more or less with the functioning of one hemisphere. Today, the lateralization of personality differences is often investigated by examining the cerebral activation under resting state conditions (e.g. Harmon-Jones et al., 2010; Wacker, Chavanon, & Stemmler, 2010). But to some degree they neglect the fact that personality is not static activation pattern. It is the ability to adapt to the specific demands of the situations. Therefore, it is necessary to assess differences under baseline conditions *and* under specific, varying conditions. For example, Jostmann and Koole (2010) demonstrated that performance differences between participants emerged or reversed under specific, demanding conditions as compared to baseline. Therefore, it is necessary to investigate structural, as well as dynamic parameters to obtain a more adequate understanding of personality and its lateralization.

As mentioned above, each level or system is constituted of different subsystems, which can be more or less allocated to different brain regions. The aim of the present work was twofold. On the one hand, existing findings indicating a lateralization of cognitive functions associated systems within the PSI theory should be confirmed and validated. On the other hand, new insights in the dynamic interconnection and functioning of lateralized subsystem-functioning should be gained. Three different experiments were conducted to 1) *indirectly* measure the laterality of the *implicit affiliation motive* (Chapter 2), 2) *directly* measure lateralized brain activity associated with the implicit affiliation motive, including a profound analysis of the underlying brain regions associated with the affiliation motive (Chapter 3), and 3) assess the role of the left versus right hemisphere during motivational processes coping with stress and how this mechanism is possibly moderated by personality differences (Chapter 4).

The Framework of the Personality Systems Interaction Theory

According to the Oxford English Dictionary, personality is “the combination of characteristics or qualities that form an individual’s distinctive character“. But what are these characteristics or qualities, specifically? Over the past decades, different psychological schools tried to tackle and approach this problem from very different angles and views. For example, personality has been described in terms of habit formation and learning theories (Hull, Skinner), differences in the arousal system (Eysenck, Pavlov), affect and the sensitivity for reward and punishment (Freud, Gray), social motives, such as power or affiliation (Murray, Atkinson, or McClelland), or self and self-development (Rogers, Erikson). In the seventies and eighties of the past century, the concept of mental contents such as beliefs, expectations, or causal attributions gained attention and was added to explain and predict behavior. But it seemed as if these different approaches mainly focused on their field and research topics and disregarded each other predominantly.

The PSI theory (Kuhl, 2000, 2001) is not meant to replace existing theories of personality or content-based approaches, but to extend them. Of course, all of the aforementioned theories of personality and especially the concept of cognitive content may have a huge impact of individual goal-directed behavior, but since their huge interindividual variability, it seems difficult to establish general laws to predict individual behavior. Therefore, a functional and dynamic approach added to existing theories might be promising for explaining and predicting individual behavior.

PSI is a hierarchical based and functional approach, which integrates findings from different psychological schools, as well as research results from experimental psychology and neurobiology. The PSI theory comprises seven different levels of personality functioning. Each level is more or less related to one of the above-mentioned leading psychological schools. It is important to mention that each level and therefore each theory of personality by itself suffices to explain specific behavior under specific circumstances. On the basis of the detrimental effect of reward on intrinsic motivation, Kuhl (2000) shows how each level alone may explain this effect. But one key feature of PSI theory is the analysis of the functional architecture underlying mental systems and their interaction. In contrast to other concepts of personality, PSI explicitly denotes the importance of innersystemic connectivity. Within the PSI framework, personality as such is defined as the dispositional strength and excitability of psychological systems on the one hand *and* the interaction or connectivity between these systems on the other hand. Therefore, the same phenotypical behavior can have its origin in completely different psychological systems or levels within the PSI framework.

PSI distinguishes between three lower levels, three higher levels, and one level mediating between the lower and higher levels. Each level is also subdivided into a primarily behavior-focused or experience focused function. It is assumed that lower levels are phylo- and ontogenetically older than higher levels. Additionally, the computational complexity of each level increases, as well as the degrees of freedom in behavior control. For example, the amount of possible outcomes for a given stimulus is very limited for the lowest level. Here, behavior is limited to simple S-R associations, where a stimulus triggers a very specific reaction to it. On the other hand, the degrees of freedom are highest for the most complex level of integration, i.e. integrated self representations as guidance for decision making (Kuhl & Koole, 2008). On this highest level, an environmental stimulus may lead to very different reactions, depending on the integration and access to self relevant information, such as a person‘s needs, values, or integrated social norms. It is the access to self referential information, i.e. the self system, which defines the amount of action alternatives available to a given stimulus. In the following, these are the seven levels of personality functioning:

1) *Elementary Cognition:* intuitive/automatic behavior control and object recognition
2) *Temperament:* motor activation and sensory arousal
3) *Affect:* positive and negative affect
4) *Progression versus Regression:* stress- and coping dependent progression (top-down) versus regression (bottom-up), which represents the mediating level
5) *Motives:* preconceptional instrumental and experiential motives
6) *Complex Cognition:* conceptually represented specific and global goals
7) *Agency:* a disciplined versus integrative form of volition.

Seven Levels of Personality Functioning

Level 1: Elementary Cognition

This most basic level in the PSI architecture comprises the two subsystems *intuitive behavior control* and *object recognition*. Intuitive behavior control is closely related to the notion of habits and classic learning theories (behaviorism). They are based on automatic routines triggered by a stimulus or "object" and are not necessarily conscious. Examples for acquired routines in our everyday life are small talk or the intuitive exchange of mother and baby (Kuhl & Koole, 2008). The latter case seems to be more in line with the colloquial term of intuition. Habits are not only largely unconscious processes without involvement of higher executive functions, but also largely independent of incentives. Incentives or complex cognitions may co-occur with habits, but such connections are not mandatory.

The key function of the object recognition system is to recognize specific, single objects, independent of the actual context. As the term "recognition" implies, to recognize a specific object it is necessary to have seen it before. This is especially required if an object is potentially dangerous for the organism. Therefore, the perceptive system associated with the object recognition system allows to recognize the same object or category of objects appearing in different situations and contexts.

Although intuitive behavior control and object recognition “only” represent the basic level in the PSI hierarchy, they are two of the four fundamental cognitive *macrosystems*, which are necessary to build the minimal architecture of a self-regulating personality system. Their mutual inhibition and activation build the core principles of the PSI theory. In the following section the four macrosystems and their innersystemic connections will be presented in greater detail.

Level 2: Temperament

With the second level, a general energization is introduced to the model. Within the PSI framework it is referred to as *temperament*, but the concept is narrowed down from a functional point of view. It constitutes two different dimensions of energization, *sensory arousal* [T -] and *motor activation* [T +]. On the one hand, sensory arousal lowers the perceptual threshold, which intensifies the experiences of environmental cues, on the other hand, motor activation increases the readiness to engage in motor action, so that behavior gets more impulsive. It can be assumed that the neurobiological basis for temperament is the Ascending Reticular Activation System or ARAS, which is phylogenetically one of the oldest portions of the brain. Both subsystems are closely related to Eysenck’s (1967) concepts of extraversion, which describes a general tendency to strive for activity and sociability, and neuroticism, which represents a general emotional lability.

From a functional or theoretical point of view, temperament and affect are easily to distinguish, but not necessarily on the measurement level, because both are closely related and may co-occur. Affects (level 3) are always in close relationship to objects, which trigger the affective reaction. Contrary, the two temperament dimensions are independent from internal or external incentives, but they may intensify the experience of positive and negative affects (Kuhl, 2001). Therefore, temperament can also be seen as an amplifier across all levels of personality. More specifically, Kuhl (2009) describes three effects of motor activation:

1. Elevation of preparedness to recall behavior routines
2. Elevation of intensity of positive affect, if present
3. Intensification of goals, if present

and also three effects of sensory arousal:

1. Lowering of the perceptual level for the object recognition system
2. Elevation of intensity of negative affect, if present
3. Intensification of sense of self and self-awareness.

Level 3: Affect

The third level adds positive or negative *affect* to the PSI hierarchy. In contrast to the temperament level, affect is linked to specific objects, which increase or decrease affective states. Positive and negative affect are assumed to be two separate dimensions, instead of two poles of the same dimension. The assumption that the two affective states are not one, but two dimensions, seem to contradict everyday life experience. Feelings are good, if they are not bad and vice versa. But there are some good reasons from empirical findings that affect is dissociable in two separate dimension. For example, Elliot and Thrash (2002) showed factor analytically that different measures of positive (i.e. extraversion, positive emotionality, and behavioral activation system) or negative affect (i.e. neuroticism, negative emotionality, and behavioral inhibition system) loaded on two factors. Cacioppo and Berntson (1999) point out that a separation of positive (appetitive) and negative (aversive) processing at very early stages opens a larger amount of action alternatives than a bipolar model could predict.

Therefore, positive affect [A +] is related to elated emotion such as satisfaction or joy, whereas inhibited positive affect [A (+)] may be experienced as the “absence” of emotions, aloofness, dejection or depression. Negative affect [A -] is often related to threats, accompanied by feelings of anxiety or sadness, whereas inhibited negative affect [A (-)] is experienced as feelings of relief, relaxation and calmness (Kuhl & Koole, 2008).

Level 4: Progression vs. Regression

The fourth level within the PSI addresses the differentiation of top-down versus bottom-up processing. Is the actual behavior and experiencing predominantly controlled by the three low level systems or by the high level systems? For the former, the term *regression* is coined by Kuhl (2001) and is closely related to the Freudian concept of regression, which describes the relapse to ontogenetically early acquired behavior and habits. *Progression* in contrast, describes the condition of higher-level control on the behavior of an individual.

Level 4 serves a “relational operator”, where information from higher and lower levels are compared and computed. Typically, higher-order systems inhibit the impulsivity and uncontrollability of lower-level functions. It is assumed that the hippocampus plays a mediating role between top-down and bottom-up processing modes. But the functionality of the hippocampus as a mediator seems to be highly stress-dependent (Sapolsky, 1992). The hippocampus is densely packed with mineralocorticoid and glucocorticoid receptors. The former ones have an extremely high affinity for the stress hormone cortisol, whereas the latter ones only have a low affinity. Under no stress or moderate stress conditions, indicated by a low level of cortisol, the mineralocorticoid receptors are occupied, which stimulates and activates typical hippocampus functions. With increasing stress level, and therefore elevated cortisol levels, more and more glucocorticoid receptors are occupied. The hippocampus gets over stimulated leading to a functional deactivation, which in turn inhibits the inhibition of impulsive behavior (de Kloet, Oitzl, & Joëls, 1999; Kuhl, 2001; Kuhl & Koole, 2008).

Level 5: Motives

Motives add an “intelligent” form of need representation to the PSI hierarchy. Needs already exist in a very basic form, maybe settled already before the first level. This basic needs represent the core of the overlying levels, but they are pre-cognitive and pre-affective (Kuhl, 2001). To put it differently, a need represents an organismic specified value, how much affiliation, autonomy, or achievement needs to be attained (see also Bischof, 1993). Motives are beyond this simple form of needs. A motive may be characterized by a global integration and interconnection of 1) basic needs, 2) relevant objects and action alternatives, 3) affects, which indicate the needs and incentives and prepare the organism for the according action, and 4) a general sensory arousal and motor activation (Kuhl, 2001). Additionally, motives incorporate information from the extension memory, e.g. integrated self-representations. Therefore, motives allow for an intelligent pursue of basic needs by considering internal and external context configurations (Kuhl & Koole, 2008)

Likewise the other levels, the fifth level is distinguishable in two classes, *instrumental motives* and *experiential motives* (Kuhl & Koole, 2008). The *achievement* and *power motive* are instrumental to a greater extend, because for their clear means-end relation to satisfy the subjacent need. The *affiliation motive* and interrelated the need for self-growth are experiential motives. They are characterized by a more holistic enactment of the motive satisfaction and a close relationship to the intuitive behavior control system (level 2) and the activation of integrated self-representations (level 7). Because the affiliation motive is of particular importance for the present work, it will be discussed in greater detail in one of the following sections.

Level 6: Complex Cognition

The sixth level introduces two modes of complex cognition, *analytic thinking* and *holistic feeling,* following the notion of Jung‘s (1990) dualism of *thinking* and *feeling.* Thinking is characterized as a more or less conscious process, with verbally explicable logical sequences of operations. Feeling in contrast is not fully explicable and represents a vast structured form of experiential knowledge from different systems, including affects and emotions (Kuhl, 2001).

Both seem two have an analogous subsystem on level 1, the intuitive behavior control and object recognition system, but they represent a completely different level of information integration. In contrast to Jung‘s typologies, Kuhl emphasizes the interconnection of thinking and intuition on the one hand, and feeling and object recognition on the other hand. This vertical antagonism and interconnectivity is the basis of modulation assumptions and therefore the dynamic interaction of systems within the PSI theory (Kuhl, 2000, 2001).

Level 7: Agency

The highest level within the PSI architecture describes two different top-down mechanisms, which enable people to control their thoughts, feelings, and behavior (Kuhl & Koole, 2008). The two systems associated with regulation mechanisms are the intention memory and the extension memory. As it will be explained later in greater detail, the intention memory is closely related to the symbolic representation of difficult action sequences and plans, while inhibiting the intuitive behavior control to prevent a premature action initiation. The extension memory is a sub-symbolic memory network, which integrates personally relevant experiences. The regulation process associated with these two highest levels of information integration are called *self-control* (intention memory dependent) versus *self-regulation* (extension memory dependent). Self-control is a more conscious and explicit top-down regulation primary for the achievement of objects and goals. Needs and other self-aspects may be inhibited during this regulatory process to prevent the system to digress and depart from the present goal. Self-regulation in turn is an implicit way of top-down regulation, where the needs from the other levels are considered and coordinated (Kuhl, 2001).

As mentioned earlier, higher levels are assumed to develop ontogenetically later and therefore depend even more one‘s individual history of development. Thus, it seems plausible that some people may show underdeveloped higher levels of personality functioning, which in turn will limit their amount of action alternatives. Critical life events for example, such as heavy traumata, may restrain the access to self-referential information in a way that only lower levels are sufficient to determine and therefore explain behavior. Imagine a patient with an obsessive-compulsive disorder in consequence of a traumatic incident. The obsessive behavior can be interpreted as a function of the most elementary subsystems of the first level: the intuitive behavior control and the object recognition system (Kuhl, 2009). The intuitive behavior routines, like washing hands or checking the door lock, are executed without any connection to higher levels. They are carried out without incorporating needs, goals, or personal values. In corporation with a highly activated objection recognition system, which is discrepancy oriented, a very rigid feedback system of control and executing instance is established.

Four Macrosystems

Having introduced the seven levels of the PSI architecture, it remains open to explain how this distinct levels are able to form something like a functioning personality. Although all seven levels are necessary to understand and describe the complex and multifaceted behavior of people, four systems are of special importance. They form and represent the core assumptions of the PSI theory. Therefore, it seems necessary to describe this so called *macrosystems* (i.e. extension memory, intention memory, intuitive behavior control, and object recognition system) in greater detail (see also Table 1).

Extension Memory

The extension memory is the experienced focused system on the seventh level. It is conceived as a large network, which contains, stores, and integrates all personally relevant memories and implicit self-representations, such as needs, preferences, (implicit) goals, and values. Because of its huge extension and vast amount of information processing, it is assumed to work in a parallel-holistic manner, similar to parallel-distributed processing networks introduced by Rumelhart, D. C. McClelland, and the PDP Research Group (1986). A network like this is able to process multiple sources of information at once while simultaneously considering all requirements given (multiple constraint satisfaction; see also Smith, 1996). Therefore, it seems not necessary or even not possible that the content of the extension memory is fully explicable. It works primarily implicitly in an unconscious or preconscious manner.

It may be assumed that this highest and most complex form of processing developed specifically for the interpersonal exchange between human beings (Kuhl, 2005a). To fully understand another person with their own complex personality and multiple facets and not only superficially by focusing only single aspects, a system is needed, which works in a parallel-holistic manner, such as the extension memory with the integrated self-system. Because of the assumed phylogenetic close relationship between the development of the extension memory and the need for interpersonal exchange, it seems plausible that this also holds for the ontogenetic self-development. Kuhl (2000) called this self-developmental process *system-conditioning assumption*. It represents a generalization of the classical conditioning hypothesis. If two subsystems are repeatedly activated within a critical time window (e.g. less than 800 ms), the association is constantly strengthened. For example, if a child‘s positive or negative expression of the self-system is followed by the appropriate reaction of the mother (e.g. encouraging voice, eye contact, touching, and so forth), the association between self-system and affect-regulating subsystems is strengthened. As a result, after a sufficient amount of trials, the external stimulation from the mother is no longer needed. The self-system is capable to regulate “itself”, which is the basis for the fourth and fifth modulation assumption, *self-relaxation* and *self-motivation*, respectively (see Figure 1; Kuhl, 2000, 2001). The affective state which characterizes the functioning of the extension memory best, could be described as relaxed or calm, or in terms of the PSI terminology, inhibited negative affect [A(-)].

But which are the neuroanatomical structures that may accomplish this vast computational effort mentioned above? There is a large body of literature, which supports the assumption that most of the properties and characteristics associated with the extension memory and the self-system are related the right hemisphere, especially the right prefrontal cortex, and the hippocampus. For example, the right hemisphere is more activated during implicit self-representations (Kircher et al., 2002; Molnar-Szakacs, Uddin, & Iacoboni, 2005), self-relevant aspects (Craik et al., 1999), retrieval of self-related episodic memories (Tulving, Kapur, Craik, Moscovitch, & Houle, 1994), shows larger semantic networks (Beeman, Friedman, Grafman, & Perez, 1994; Bowden, Jung-Beeman, Fleck, & Kounios, 2005), is more involved in the recognition of emotions (Adolphs, Damasio, Tranel, Cooper, & Damasio, 2000), and when making evaluations about the self (Schmitz, Kawahara-Baccus, & Johnson, 2004).

Additionally, the hippocampus seems to play a major role in the encoding and retrieval processes into the self-system, but also as a stress-dependent mediator of top-down versus bottom-up processing, as mentioned earlier (level 4). Although the hippocampus seems not to be the functional location of memory contents, it serves as organizer and configurator of internal and external stimuli (Jacobs & Nadel, 1985; Sutherland & Rudy, 1989), and perceptual, spatial, and cognitive representation (J. L. McClelland, McNaughton, & O'Reilly, 1995; Squire, 1992). It is also involved in the conditioning of emotional and motor reactions to combined stimuli (Gluck & Myers, 2001; Schmajuk & DiCarlo, 1992), as well as spatial orientation (O'keefe & Nadel, 1978). Together with the stress-dependent regulation of high- or low-level processing, the hippocampus seems to be crucially involved in the dynamic interaction between the macrosystems, which will be explained in greater detail in a further section.

Intention Memory

The intention memory is closely related to the colloquial notion of conscious thinking. Similar to the extension memory, it is also a high level system allocated in the seventh level of the PSI hierarchy. While the extension memory is conceived to work more in a subconscious, holistic, and parallel manner, the intention memory works in a more conscious, analytical, and sequential way. Goschke and Kuhl (1993) showed that the functioning of the intention memory is beyond the mere representation of plans, goals, and opportunities for executing the actions, which is to some degree comparable to functions of working memory (Fuster, 1995). The affective state that is related to the intention memory can be described as factual, unemotional, or focused. In terms of the PSI, it is associated with inhibited positive affect [A(+)].

According to the PSI theory, the intention memory is specialized for the planning, activation, representation, and maintenance of (difficult) intentions (Kuhl, 2000, 2001; Kuhl

& Kazén, 1999). For example, the intention memory is needed, if goals or plans cannot directly put into action, because a proper occasion to perform the intended action did not arose, yet. The intention to perform an action increases the activation of specific declarative representations, which Goschke and Kuhl (1993) called the *intention superiority effect*. But the intention memory is also needed, if a goal is too difficult to be achieved with the typical behavioral routines available from the intuitive behavioral control system. Therefore, typical impulsive routines need to be inhibited, until a proper action alternative or solution is found. A premature and impulsive activation of available routines may not suffice to accomplish the goal aimed for. Therefore, a second function of intention memory is the inhibition of the executing system, i.e. the intuitive behavior control.

	Behavioral Systems (left hemisphere)	**Experiential Systems (right hemisphere)**
	Intention Memory	**Extension Memory**
High-inferential Systems	• analytical (critical feature) • sequential • vulnerable • slow • accurate • decoupling from emotions	• holistic (family resemblance) • parallel • robust • fast • impressionistic • close interaction with autonomic reactions
	Intuitive Behavior Control	**Object Recognition**
Low-inferential Systems	• contextual • cross-modal • presence and future-oriented • anticipation • holistic • robust	• decontextualized • modality-specific • past-oriented • recognition • analytical • vulnerable

Table 1: ***Laterality and Functional Aspects of the Four Macrosystems.***

Notes. Adapted From Kuhl (2000).

Intuitive Behavior Control

The key functions of the intuitive behavior control system have already been presented in the first level of the PSI hierarchy. It is a largely implicitly working holistic system, which is able to integrate and process contextual information from different modalities simultaneously in a parallel manner (Kuhl, 2000). Because of its fast and cross-model functioning and the decoupling of conscious planning, as it takes place within the intention memory, it works largely unconsciously. A functional location of the intuitive behavior control seems to be posterior areas of the right hemisphere (Kuhl, 2001), because it is closely related to spatial perception and spatial orientation (Goodale & Milner, 1994; Posner & Petersen, 1990; Posner & Rothbart, 1992). Because the intuitive behavior control system is assumed to organize and regulate the implementation of action sequences, it is directly related to the intention memory. Typically, high level systems inhibit low level systems (top-down inhibition). Therefore, it seems plausible that planning and maintenance of intentions inhibits intuitive behavior routines, as indicated as a dashed line between these two macrosystems in Figure 1.

Object Recognition System

In contrast to the intuitive behavior control, the object recognition system separates sensations from different modalities and represents them decontextualized from their former occurrence. This enables the system to identify objects or classes of objects independent of the particular context (Kuhl, 2001). Therefore, the object recognition system is backward-oriented, because objects have to be learned, to be recognized.

One core feature is the sensitivity for discrepancies in the environment, and the explicit representation of them. These perceptual systems seem to be of special importance in detection of threatening or deviant objects. According to PSI theory, discrepancies-perception is related to the experience of threat and negative affect. A sudden perceptual shift to a potential threatening object may save the whole organism. But this relation to negative affect bears risks and chances. On the one hand, a longer persistence on negative or stressful objects may harm the whole organism (e.g. Sapolsky, 1992), on the other hand, an adequate regulation and integration of the threatening experience may help to develop and „grow“ (Kuhl, 2001). To accomplish this potential self-growth and self-development, a close connection to an integrating system is needed, i.e. the extension memory. Comparable to the top-down inhibition between the intention memory and intuitive behavior control, there is also an inhibition between the extension memory and object recognition (dashed line on the right side of Figure 1).

The Dynamic Interactions - Modulation Assumptions

As mentioned earlier, one of the core features of the PSI is the assumption of a dynamic interaction of the macrosystems and therefore, the seven levels, especially between high and low levels (Kuhl, 2000, 2001; Kuhl & Koole, 2008). Each of the four macrosystems is related to specific affective states. The interactions, and therefore “communication” between them, are modulated by affects and affective changes. From this point of view, positive and negative affects seem have a dual function. On the one hand, they establish incentive and object related approach and avoidance behavior (level 3), on the other hand they regulate the information exchange between high and low level systems (especially between level 1 and level 7). The next section will explain the dynamic interactions between the macrosystems and the conditions how and when an exchange between different systems can be established.

Having introduced seven different levels of personality functioning, including four macrosystems, which mutually inhibit each other (with a stronger basal top-down inhibition due to the intrinsic control functioning of higher order levels), it still remains unclear how a dynamic interaction between the systems, and therefore different levels, can be established. Due to the mutual inhibiting function, a mere activation of one of the macrosystems would only lead to an aggravation of the existing inhibition. As mentioned already, affects and affective changes play a dual role in the PSI theory. According to Kuhl (2000, 2001), affects modulate the antagonistic dynamic relationship between the four macrosystems, by strengthening or releasing the inhibitory activation between them (see also Figure 1). The specification, which and how different affective states modulate these interactions, are termed *modulation assumptions* (Kuhl, 2000).

1. Modulation Assumption (Volitional Facilitation)

Positive Affect (A +) releases the initial inhibition of the pathway between intention memory and the intuitive behavior control system, whereas downregulated (inhibited) positive affect [A (+)] facilitates maintenance of intention in the intention memory by strengthening the inhibitory relationship between these two macrosystems. The first modulation assumption already reveals a basic difference between content-based personality theories and PSI theory. It can explain why a person can have an intention, but not the ability to put it into action. Positive affect is needed to establish the connection and therefore the “communication” between intention memory and intuitive behavior control system. In a series of experiments using the classical Stroop task, the volitional facilitation effect could be demonstrated (Kazén & Kuhl, 2005; Kuhl & Kazén, 1999). Positive prime words presented directly before the Stroop task removed the classical Stroop interference effect („Stroop-Killer“). This effect was interpreted as a release of the inhibition from the loaded intention memory to the intuitive behavior control system.

2. Modulation Assumption (Self-Facilitation)

Downregulation of negative affect [A (-)] facilitates access to integrated self-representations and other contents of the extension memory by strengthening the inhibitory effect the extension memory has on sensory input stemming from unexpected or unwanted information provided by the object recognition system.

3. Modulation Assumption (Volitional Inhibition)

Activation of the intention memory reduces positive affect [A +], and therefore the enactment of intentions, which is the reversal of the first modulation assumption. For example, state-oriented participants (a nonpathological form of depression) and depressed patients enact fewer intentions after induction of an uncompleted intention (Kuhl & Helle, 1986; cited in Kuhl, 2000).

4. Modulation Assumption (Self-Relaxation)

The fourth modulation assumption is the reversal of the second: it describes the self initiated downregulation of negative affect [A -] by the extension memory. Whereas the global formulation of the second modulation assumption allows also external initiation of inhibited negative affects, the fourth describes the self-regulated form of downregulation.

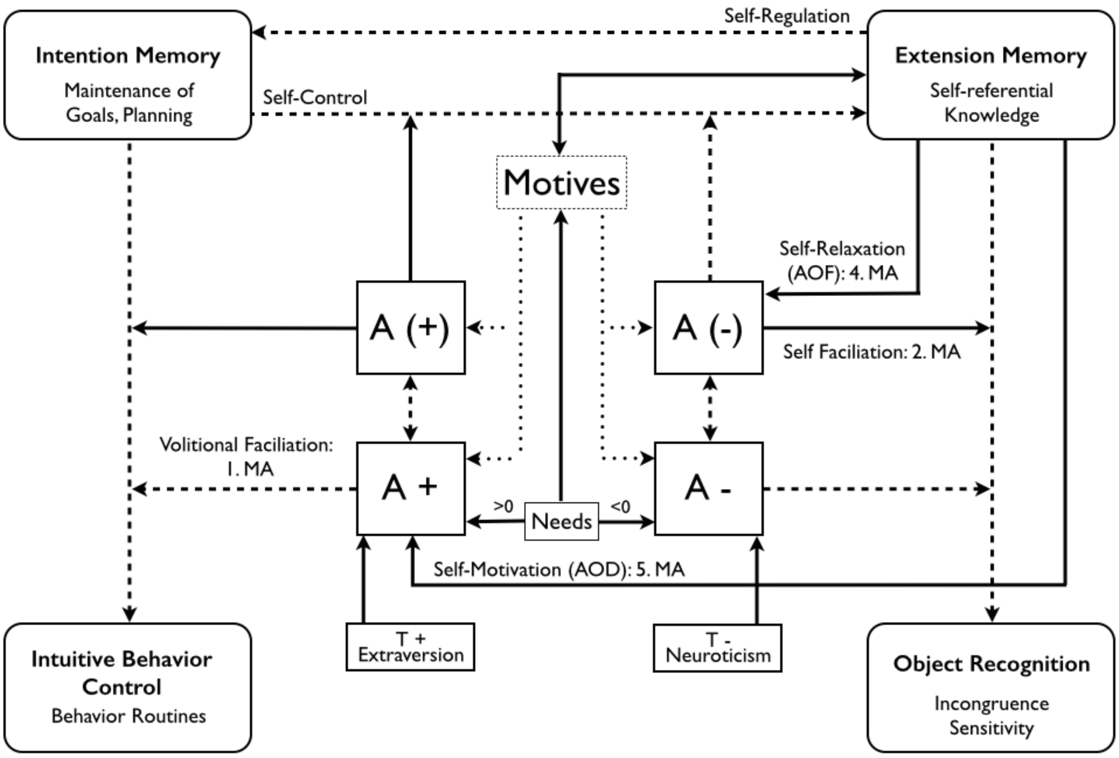

Figure 1: ***Dynamic Interaction Between the Levels of Personality Functioning, Including the Basic Modulation Assumptions.***

Notes: Solid Lines Indicate a Facilitatory Connection; Dashed Lines Indicate an Inhibitory Connection; Dotted Lines Indicate a Modulatory Connection; MA = Modulation Assumption; AOF = Failure Related Action Orientation; AOD = Demand Related Action Orientation.

5. Modulation Assumption (Self-Motivation)

Self-generated positive affect by activation of appropriate self-representations within the extension memory, allows the initiation of intentions and goals from the intention memory. The fifth modulation assumption seems to be very similar to the first one, because it describes the general mechanism that positive affect releases the inhibition between the intention memory and the intuitive behavior control system. But like the fourth modulation assumption, the involvement of the extension memory, and therefore the independence of external stimuli and incentives, is crucial. This assumptions is comparable with the notion of intrinsic motivation and self determination (Deci & Ryan, 1991).

6. Modulation Assumption (System Conditioning)

The system conditioning assumption describes not exactly a modulation between the different macrosystems, but it explains how the self-system, as part of the extension memory, is able to participate in action control. Whenever two subsystems are repeatedly activated within a time window, the pathways between the two systems is strengthened (Kuhl, 2000). This generalization of the classical conditioning principle explains the development of self-relaxation (fourth modulation assumption) and self-motivation (fifth modulation assumption).

For example, if the negative emotional expression of a child is answered by the reassuring vocalization and touching of the mother, the negative affect should be (externally) downregulated. Each time, the association between the child‘s self-system and the affect generating systems is strengthened, until the child is able to downregulate the negative affect without external stimulation. Similarly, the association between positive affect generating systems and the self-system is strengthened, if the mother reacts for example with encouraging vocalizations or initiation of eye contact (Kuhl, 2000).

7. Modulation Assumption (Self-Actualization)

The last modulation assumption exemplifies the necessity of affective changes to maturate the self-systems, with its two components *self-development*, which is the integration of (negative) experiences into the self-representional system, and *volitional efficiency*, the ability to enact the own intentions (Kuhl, 2000). Self-development requires the shift between negative states and the activation of the self-system. On the one hand, it is necessary to experience and persevere the negative affective state, on the other hand, an activation of the self-system is needed to integrate this experiences (*emotional dialectics*). Similarly, for volitional efficiency also an affective change is needed. According to the first and third modulation assumption, maintenance of difficult intentions needs downregulation of positive affect and inhibition of it, whereas positive affects needs to be upregulated to enact the intention. Volitional efficiency describes this self-regulated affective change.

Action versus State Orientation

In the last sections the author presented the different levels of personality functioning, the four most important macrosystems, as well as the modulation assumptions, which constitute the dynamic interactions between the macrosystems. The four macrosystems and their connection to affective states represent the sensitivity and responsiveness of specific systems, so called structural parameters (e.g. extraversion or neuroticism). But the core assumption of the PSI theory relies on the dynamic connection between these structural parameters. It is not only the excitability of a specific system, for example the sensitivity for negative affect [A-], but the ability to downregulate the negative affect (Kuhl, 2001). This interconnection can be seen in Figure 1 as an arrow from the extension memory to the inhibited negative [A(-)] affect. The ability for a self-generated downregulation of negative affect is called *failure related action orientation* (AOF; Kuhl, 1994a) and is explained in the fourth modulation assumption. In contras, the reversal, i.e. the inability to downregulate, is called *failure related state orientation* (SOF). AOF versus SOF describes the self-regulatory mechanism on the right side of Figure 1. But it has also its analog on the left side. When faced with difficult intentions, the intention memory is loaded and therefore the inhibitory strength on the intuitive behavior control is increased (third modulation assumption). The ability to upregulate positive affect from the self-system, to establish the connection between the planning and the executive systems, is called *demand related action orientation* (AOD), and in turn the inability *demand related state orientation* (SOD, fifth modulation assumption).

In contrast to structural parameters, *dynamic parameters* (AOF versus SOF and AOD versus SOD) seem to be more influenced and constituted by socialization conditions and not so much by genetic factors (Kästele, 1988; Kuhl & Völker, 1998). The sixth modulation assumption exemplifies nicely, how environmental conditions and the adequate reaction to affective expressions in the early childhood may form the dynamic parameters.

The first and the fifth modulation assumption, and therefore the distinction between AOD and SOD, are of special interest for the present work (Chapter 4). During demanding situations, i.e. a highly loaded intention memory, positive affect is needed to put the intentions into action. It seems largely irrelevant how the positive affect may be generated, internally or externally. External positive affect (encouragement) could either be a valued incentive or also the support of significant others (e.g. Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003). If no external cue is available, internal, i.e. self-generated positive affect, is needed to establish the connection between the intention memory and the intuitive behavior control (self-motivation according to the fifth modulation assumption).

The Affiliation Motive - Having the Heart in the Right Place

Unlike the four macrosystems, motives are not explicitly mentioned within the modulation assumptions. Nevertheless, motives seem to modulate and configure the activation of the macrosystems to optimally satisfy the underlying needs in an appropriate way. This means that different motives may strengthen or inhibit specific system configurations to ensure the realization of a need satisfaction (Kuhl, 2001; see also Figure 1). It seems plausible that the different motives are more closely associated with specific macrosystems (Kuhl, 2000). For example, the need for achievement seems to be associated with intentional planning and problem solving, which are prime features of the intention memory. The need for power may benefit most from access to integrated self-representations and the intention memory. On the other hand, the need for affiliation depends on the intuitive behavior control to easily engage in relationships (Kuhl, 2000), but also on access to self-representations to foster a deeper understanding of the counterpart and self-growth (Kuhl, 2000). Therefore, motives seem to have a central role in the accommodation of the organism to environmental requirements and changes (Kuhl, 2001). For an optimal consideration of all needs, values, and goals, a close relationship to the extension memory is assumed. To put it differently, the extension memory is the only system, which is able to provide all information from the organism to optimally modulate the connections between the different macrosystems (Figure 1).

Besides a general close relationship between extension memory and the three motives, this should be especially true for the affiliation motive for two reasons. Firstly, Kuhl (2000, 2001) assumes that *system-conditioning* represents the central mechanism to form the interconnection between subsystems. In both examples for the development of the self-regulated forms of action control (i.e. downregulation of negative affect, as well as the upregulation of positive affect) significant others (e.g. the mother) are critically involved in the developmental process. Secondly, the self-system and therefore the extension memory especially benefits from the direct interpersonal exchange with other individuals. As Kuhl (2005a) hypothesizes, that the extension memory developed due to and especially for the contact and exchange with other individuals.

Besides a close relationship to the extension memory for the “deep” form of exchange with others, the affiliation motive can also be nurtured by a more superficial form of communication. To routinely interact with others, a system is needed, which is also able to integrate information from different modalities and context information in a fast way to "translate" it into adequate behavioral responses. But this integration level does not need the same depth of processing (which could be cumbersome to some extend) as for a profound personal exchange. Therefore, this superficial form may rely to a greater extend on the intuitive behavior control system than on the extension memory.

Having said this, what can be inferred from it? As argued, both forms of affiliative exchange, the deep and the superficial form, rely on a close interconnection with either the extension memory or the intuitive behavior control system. As demonstrated earlier, both macrosystems seem to be neurophysiologically located within the right hemisphere. Interestingly, the general functioning of the right hemisphere, or more specifically the right frontal cortex, can be described in terms which seem to be necessary to cope with social situations. For example, Rotenberg (1993, 2004) points out that a function of the right hemisphere is the simultaneous capture and integration of a complex, ambiguous polysemantic context. The reduction of complex social situations to concrete elements would meet the requirements to fruitfully interact with other persons in a deeper way. Therefore, it seems plausible that the functional location of the affiliation motive should also be located in the right hemisphere. First evidences for this hypothesis are provided by a series of experiments by Kuhl and Kazén (2008). The authors found in visual hemifield studies a right hemispheric processing advantage for affiliation related primes. Moreover, this effect was more pronounced for participants with a high implicit affiliation motive.

Additionally, several forms of social behavior, which are closely related to the affiliation motive, have also been linked to a predominantly right hemispheric processing. For example, empathy has been related to the right posterior cortex (Adolphs et al., 2000; Decety & Lamm, 2007) and the right PFC (Shamay-Tsoory, Adler, Aharon-Peretz, Perry, & Mayseless, 2011; Tullett, Harmon-Jones, & Inzlicht, 2012). Similarly, the right PFC has been linked to the attribution of others' mental states (Platek, Keenan, Gallup, & Mohamed, 2004) and to cooperation (Knoch, Pascual-Leone, Meyer, Treyer, & Fehr, 2006). Moreover, patients with lesions in the right ventromedial PFC showed impaired mental states attribution (Shamary-Tsoory, Tomer, Berger, & Aharon-Peretz, 2003) or even met criteria for acquired sociopathy (Tranel, Bechara, & Denburg, 2002), suggesting a particular role of this region in affiliative processes.

Creativity, Insight, and Intuition, typically right! Right?

Although creativity as a broad construct is in the focus of attention since decades or centuries, little is known about the neural underpinnings. The problem in studying creative processes starts already with a conclusive definition of creativity. Creativity theories seem to be as diverse and complex as creativity itself. Theories can be classified in different categories such as developmental, psychometric, cognitive, problem solving and so on. Kozbelt, Beghetto, and Runco (2010) identified ten different perspectives on creativity, each of them covering different definitions, domains, levels of abstraction and empirical methods. All of the categories described by Kozbelt and colleagues are more or less scientifically or metaphorical oriented. On this spectrum psychometric and cognitive theories seem to be most promising to study creative processes and possible neural underpinnings under controlled laboratory conditions.

Guilford (1968) introduced the concept of *divergent* vs. *convergent* thinking, which became one of the standard conceptions of creativity. Divergent thinking can be defined as "cognition that leads in various directions" (Runco & Pritzker, 1999 p.577, cited in Kaufman, Plucker, & Baer, 2008). In a need for appropriate assessment methods of creativity, divergent thing became the most prominent candidate, which resulted in plenty of different tests (for an overview, see Kaufman et al., 2008). Two well-known representatives are the Torrance Test of Creative Thinking (Torrance, 1974) and the Remote Associates Task (RAT; Mednick, 1962; Mednick & Mednick, 1967). Over the years, divergent thinking tasks were not only one aspect of creativity, but became *the* creativity measurement. This oversimplification and nearly interchangeable use of the terms *creativity* and *divergent thinking* was originally not intended by Guilford himself. As criticized for example by Dietrich (2007), creativity can also easily be a process of convergent thinking and maybe creativity involves both processes. One reason for the "success" of the divergent thinking concept surely lies in the identifiability, manageability, and measurability. Besides the ongoing discussion among neuroscientists, how to define and measure creative processes, divergent thinking or variants thereof can also been seen as means to an end to assess processes beyond creativity itself. For example Mednick‘s RAT based on the assumption of associative hierarchies, which are closely related to Guilford‘s divergent thinking concept has been associated with an advantage for right hemisphere processing numerous times (e.g. Beeman et al., 1994; Bowden & Beeman, 1998; Bowden & Jung-Beeman, 2003).

But how can creativity contribute to the disentanglement of the lateralization of motivational processes? If you now consider social motives (e.g. affiliation) as a trait-like pre- or hyper-activation of specific brain regions, this pre-activation might be advantageously in solving hemisphere specific tasks or problems. There is evidence showing that the (pre-) activation of a specific region within on hemisphere spreads over the whole hemisphere, leading to a general pre-activation of other systems (e.g. Keenan, Nelson, O'Connor, & Pascual-Leone, 2001; Lee et al., 2003; Wittling, 1990). For example, Baumann, Kuhl, and Kazén (2005) showed that a unilateral activation of the right hemisphere, elicited by unilateral muscle contractions in the left hand, activated self-referential processing. Therefore, typical RAT or insight problems seem to be a prime dependent measure to investigate lateralized cognitive processes, especially when investigating functions presumably related to the right hemisphere, i.e. the implicit affiliation motive.

Electroencephalography and Asymmetries in a Nutshell

Even though the previous section showed *one* possibility to assess lateralized cognitive functions somewhat indirectly, there exists a long tradition in research in motivational psychology to measure lateralized cortical activity with EEG. In 1979, Davidson and colleagues pioneered in the field of EEG alpha asymmetries and emotions (Davidson, Schwartz, Saron, Bennett, & Goleman, 1979). They used the measured cortical activity to make inferences about the underlying emotional processes. Since their seminal paper, frontal alpha asymmetries have been linked to a variety of psychological phenomena like psychopathology (e.g. depression), state motivation (e.g. approach, avoidance), trait motivation (e.g. BIS/BAS), immune functions (e.g. killer cell activity), or neurotransmitter functioning (e.g. dopamine; for an overview see also Coan & Allen, 2003b). But what does activity or amplitude or power in the alpha band spectrum of the EEG represent? To better understand the methods and results of the following chapters, I will give a short overview and clarification of typical pitfalls when interpreting EEG alpha asymmetries. Specific literature reviews and extensive discussions about previous findings of alpha asymmetries and motivation will be given in the introduction and discussion sections of the particular chapters.

Alpha band activity is a rhythmic oscillation typically measured in the range between 8 and 13 Hz. Already Hans Berger reported and even coined the term *alpha* is his paper “On the Electroencephalogram of Man” in the 1920’s. Alpha activity can be produced by nearly all persons, when sitting relaxed and quietly with eyes closed. Because of its relative large amplitude (up to 60 µV), it is already visible without any means in continuous EEG data (Figure 2). Alpha activity can be already decreased simply by opening the eyes, but also by engaging in cognitive tasks (e.g. Davidson, Chapman, Chapman, & Henriques, 1990). Therefore, alpha is typically thought to be inversely related to mental and cognitive activity (Cook, O'Hara, Uijtdehaage, Mandelkern, & Leuchter, 1998), although there are findings contradicting this general assumption (e.g. Shaw, 1996). It has also been shown, that under specific circumstances (e.g. major depression) cerebral activity and functional efficacy may differ or even being opposed to each other (for an overview see e.g. Rotenberg, 2004).

Because of the inverse relationship between cognitive activity and alpha power, results have to be interpreted with caution. For example, a *negative* correlation between alpha power at any given site and the results from recognition task would indicate a *positive* relationship between cortical activation and performance. Hence, it is necessary to be clear about the dependent measures, i.e. alpha activity or cortical activity.

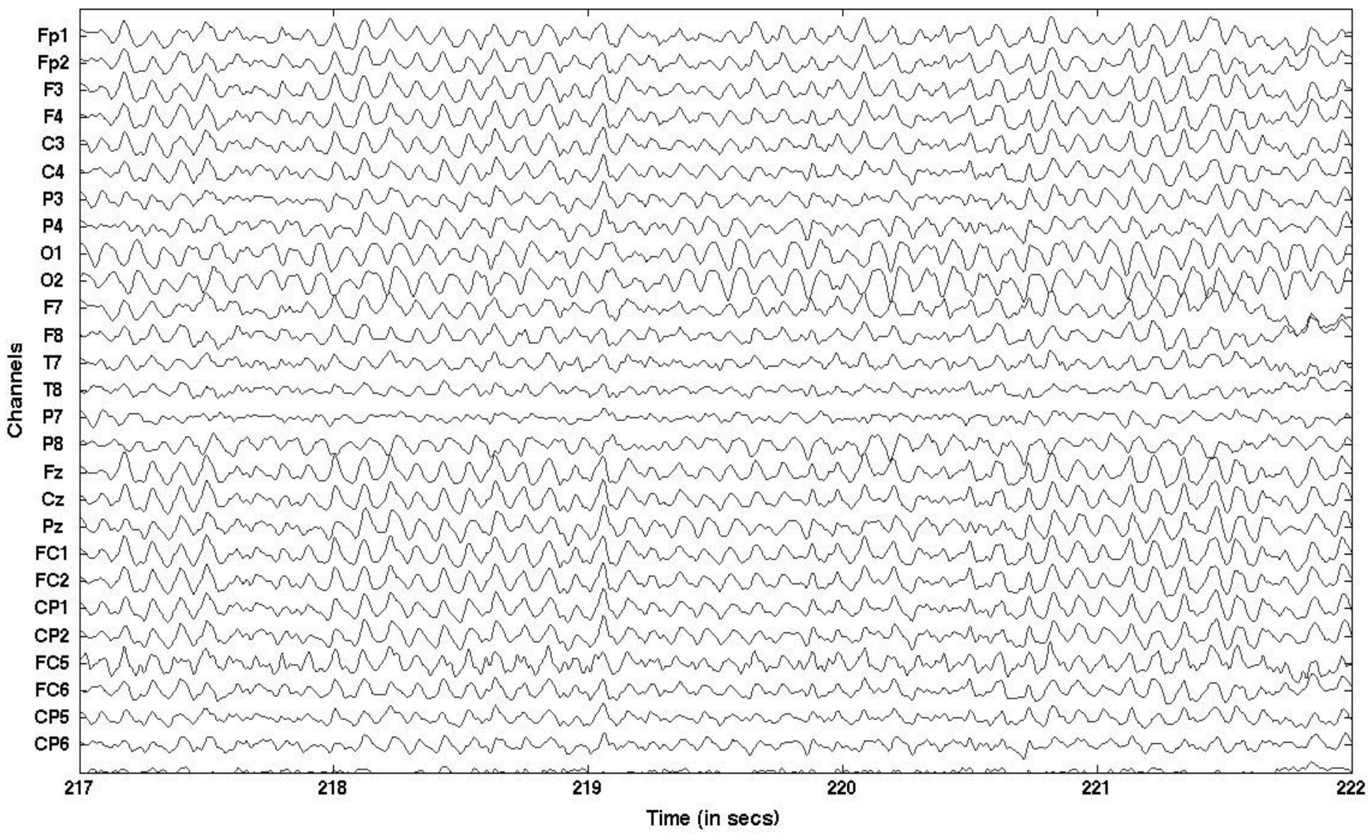

Figure 2: Five Seconds Continuous Resting State EEG with Alpha Oscillations.

Another typical dependent variable, which is very often reported in motivational research, are difference scores or often called "asymmetry scores". This scores are calculated by subtracting the natural logarithm (ln) of the right alpha power from the left ln alpha power (ln[Right] – ln[Left]) of two homologous electrode sites (e.g. F4 and F3; see Allen, Coan, & Nazarian, 2004 for an extensive description of the methodology). This is an unidimensional representation of the asymmetry of left and right activity. Higher asymmetry scores indicate a *relative* greater left cortical activity, whereas lower scores indicate a *relative* greater right activity. A problem with this simple representation is that it remains unclear, which hemisphere contributes to the asymmetry and hence only indicates a relative activity. An overly activated left hemisphere or a moderately activated right hemisphere (as compared to the homologous site) may lead to the same asymmetry score. Therefore it is necessary to inspect the alpha power at the individual sites if one is interested in the absolute activation and contribution of each site.

In motivational research, asymmetry scores are typically calculated from resting state EEG, i.e. the participants sit relaxed in an EEG chair without actively engaging in any task.

Most of the studies report a setting of 8-minutes resting state, divided in 1-minute blocks of either eyes open or closed in a balanced sequence. Tomarken, Davidson, Wheeler, and Kinney (1992) showed that the use of eight 1-minute blocks ensures an adequate internal consistency for asymmetry scores. This finding was extended by Allen, Urry, Hitt, and Coan (2004). They were able to demonstrate that the reliability depends more on the amount of blocks used for the calculation than the total time of recording. For example, eight blocks of 30 seconds length (i.e. a total recording time of 4 minutes) show a similar internal consistency as eight blocks of 60 seconds length. Despite of the possibility to use shorter a recording time, the standard approach up to now remains the use of 8-minutes resting state EEG.

But good internal consistency values alone, like Cronbach's alpha, would not suffice to accept alpha power and alpha asymmetries as a valid measurement instrument to assess psychological phenomena or personality traits in particular. An internal consistency estimation for an 8-minutes recording section could be highly driven by state characteristics. For example, Tomarken et al. (1992) and Sutton and Davidson (1997) reported only moderate retest stability estimates for alpha asymmetry scores at midfrontal electrode sites. Only by two seminal papers from Hagemann and his colleagues (Hagemann, Hewig, Seifert, Naumann, & Bartussek, 2005; Hagemann, Naumann, Thayer, & Bartussek, 2002), the contributions of state and trait parts could be clarified. They applied a latent state-trait model on the resting state data collected from multiple recording sessions over a time range of several months. They estimated that up to 60% of the variance of asymmetry measures was due to individual differences of a latent trait. Therefore, alpha power and alpha asymmetry scores seem to be a good estimation to assess trait- and state-like cognitive processes. In chapters 3 and 4 the author will use both, the trait and state features of the asymmetry scores, to show an association with personality differences (i.e. the implicit affiliation motive) and a phasic change in of the asymmetry moderated by personality, respectively.

Summary and Hypotheses

In the preceding sections, the author introduced the basic assumptions of the PSI theory (Kuhl, 2000, 2001). I explained the dynamic interaction of the seven levels of personality functioning, including the four macrosystems. The main goal of the present work is to test some predictions about individual differences in motivational processing and associated cognitive processes that can be derived from the PSI theory. Due to the modular structure of the PSI hierarchy and therefore more or less the implicitly assumed modular structure of the brain, different, dissociable brain regions should be activated for different personality structures (e.g. AOD versus SOD) under varying conditions.

There seems to be good evidence to believe that the implicit affiliation motive is closely related to functioning of the right hemisphere (e.g. Kuhl & Kazén, 2008). In chapter 2 I will show results from a study, which tested this assumption *indirectly*. As pointed out above, some specific forms of creative thinking, i.e. insight problem solving, seem also to be a function of the right hemisphere. Two basic assumptions can be taken together: 1) there is a close relationship between the functional location of the affiliation motive and the processing of insight problem solving, and 2) activation within one hemisphere will spread and pre-activate the entire hemisphere, which will facilitate the processing of other cognitive tasks (Baumann et al., 2005). Therefore, participant with a high affiliation motive should also show an advantage in processing insight problems.

The third chapter will complement the findings from the second chapter. Whereas the second chapter will show a connection between the affiliation motive and right hemispheric activation indirectly, I will take a more *direct* look. In the presented study I used resting state EEG, a typical measurement in motivational research, to measure different cortical activation patterns for participants with high versus low affiliation motive. In a next step, I used a source localization algorithm, to estimate cortical regions responsible for the activation pattern at scalp sites. The study is one of the first showing neural substrates of the affiliation motive and pioneering in the application of source localization in the field of implicit motives.

The forth chapter will tackle a slightly different aspect of lateralized functions within the PSI framework, i.e. different lateralization dynamics of AOD versus SOD participants. It has been shown that the ability to down-regulate stress due to demanding situations is highly dependent on contextual factors (Heinrichs et al., 2003), but also internal factors, such as personality differences in AOD (Quirin, Kuhl, & Düsing, 2011). According to PSI theory, the successful accomplishment of demanding situations requires the activation of the intention memory on the one hand, but also the availability of positive affect to put the intentions into action. Under standardized stress tests, such as the Trier Social Stress Test (Kirschbaum, Pirke, & Hellhammer, 1993), no external positive affect is available. Participants with better access to the regulation system, i.e. the extension memory, should be better able to down-regulate the stress reaction. Within the PSI framework, the intention memory is closely related to left frontal cortical activation, whereas the extension memory is related to right frontal cortical activation. Therefore, demanding situations should be associated with a higher left frontal activation (activation of the intention memory). Participant showing better trait-like emotion regulation abilities (AOD) should show an elevated right frontal activation and a lower stress reaction, whereas state oriented participants should show an elevated left frontal activation and a higher stress reaction.

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The only real valuable thing is intuition.

Albert Einstein

Chapter 2

Implicit Affiliation Motive Predicts Correct Intuitive Judgment

Markus Quirin, Rainer Düsing, and Julius Kuhl

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Abstract

Previous research demonstrated that affiliation primes facilitate intuitive thought (Kuhl & Kazén, 2008). We investigated whether trait tendencies towards affiliation also predict intuitive thought. Thirty-nine students filled in the operant motive test for the assessment of social motives, a variant of the thematic apperception test, and corresponding self-report scales. Nine months later, participants engaged in a remote associates task where participants intuitively indicated whether three words are semantically related. As expected, the implicit affiliation motive significantly predicted the accuracy of identifying related word triads, but neither implicit power and achievement motives, nor explicit motives did so.

In love, one and one are one.

Jean-Paul Sartre

Chapter 3

Is Love Right? Prefrontal Resting Brain Asymmetry is Related to the Affiliation Motive

Markus Quirin, Julius Kuhl, Thomas Gruber, and Rainer Düsing

Published as: Quirin, M., Gruber, T., Kuhl, J., & Düsing, R. (2013). Is love right? Prefrontal resting brain asymmetry is related to the affiliation motive. *Frontiers in human neuroscience, 7*.

Abstract

Previous research on relationships between affective-motivational traits and hemispheric asymmetries in resting frontal alpha band power as measured by electroencephalography (EEG) has focused on individual differences in motivational direction (approach vs. withdrawal) or behavioral activation. The present study investigated resting frontal alpha asymmetries in 72 participants as a function of individual differences in the implicit affiliation motive as measured with the operant motive test (OMT) and explored the brain source thereof. As predicted, relative right frontal activity as indexed by increased alpha band suppression was related to the implicit affiliation motive. No relationships were found for explicit personality measures. Intracranial current density distributions of alpha based on Variable Resolution Electromagnetic Tomography (VARETA) source estimations suggests that the source of cortical alpha distribution is located within the right ventromedial prefrontal cortex (PFC). The present results are discussed with respect to differential roles of the two hemispheres in social motivation.

Knowing is not enough; we must apply. Willing is not enough; we must do.

Johann Wolfgang von Goethe

Chapter 4

Emotion Regulation Abilities Moderate the Relationship Between Left Frontal Brain Activity and Cortisol Release After Social Stress

Rainer Düsing, Julius Kuhl, Mattie Tops, Sander L. Koole, and Markus Quirin

(under review, this version is not suitable for citation!)

Introduction

Hypothalamus Pituitary Adrenocortical (HPA) system activity and frontal asymmetry measured via electroencephalography (EEG) have both been related to stress and emotions but only a handful of studies investigated their relationships directly. These studies, however, showed mixed results. The present study follows this line of research by capitalizing on some methodological amendments and by taking account of individual differences in emotion regulation abilities (ERA), which might moderate this relationship.

The HPA system is typically aroused in response to physical or psychological stressors (Sapolsky, Romero, & Munck, 2000) leading to a release of the glucocorticoid cortisol from the adrenal cortex. In particular, social-evaluative threat as for example aroused by the broadly applied Trier Social Stress Test (TSST; Kirschbaum et al., 1993) has been found to reliably evoke a cortisol stress response (for a review, see Dickerson & Kemeny, 2004).

On the other hand, emotional responses have also been associated with frontal cortical alpha asymmetries (Davidson, 1992a; Harmon-Jones et al., 2010; Papousek & Schulter, 2002; Tomarken, Davidson, & Henriques, 1990). Whereas approach-related emotional reactions such as appetence and anger have been found to be related to relative left frontal activity (Harmon-Jones et al., 2010, for a review; but see Hagemann, Naumann, Becker, Maier, & Bartussek, 1998; Wacker et al., 2010, for reviews of inconsistent literature). For withdrawal-related emotions such as anxiety the literature on frontal asymmetry is very inconsistent (for a review, see Spielberg, Stewart, Levin, Miller, & Heller, 2008). Whereas a bunch of studies found an association between anxious arousal and relative right frontal activity (for an overview see, Engels et al., 2007), other studies found relative left frontal activity particularly when withdrawal was associated with anxious apprehension or “worry” (Engels et al., 2007; Heller, Nitschke, Etienne, & Miller, 1997; Ray et al., 2005; Simmons et al., 2013). Worry is characterized as a negative affective state involving ruminative thoughts, high verbal thought activity, and cognitive avoidance in combination with behavioral inhibition (Barlow, 1991, 2004; Borkovec, Ray, & Stober, 1998). For example, when participants were instructed to worry about an anticipated public speech on the basis of an imagination paradigm, increased left frontal activation was found (Hofmann et al., 2005). Additionally, this study found that participants with trait public speaking anxiety showed a stronger left hemispheric activation during the worry phase.

Findings of relatively left-sided activity at frontal electrode sites for worry and rumination is compatible with the role of the left inferior frontal gyrus in reappraising novel or negative experiences and assimilating them in preexisting internal working models (“schemata”) (e.g. Hayes et al., 2010). Specifically, when these experiences cannot readily be integrated, a prolonged reappraisal process might turn into rumination and worry with the consequence of increased left inferior frontal cortex activation (Hayes et al., 2010; Ochsner, Silvers, & Buhle, 2012; Salomons, Johnstone, Backonja, Shackman, & Davidson, 2007; Torrisi, Lieberman, Bookheimer, & Altshuler, 2013; see also Tops, Boksem, Luu, & Tucker, 2010; Tops, Boksem, Quirin, IJzerman, and Koole, 2014 for integrative views). Importantly, the withdrawal-related negative emotions shame and guilt, which are typically linked to social-evaluative stress (Dickerson, Gruenewald, & Kemeny, 2004) have been repeatedly associated with greater left frontal activation (e.g. Cope et al., 2010; Finger, Marsh, Kamel, Mitchell, & Blair, 2006; Michl et al., 2014).

Cortisol and Frontal Alpha Band Asymmetry: Direct Empirical Evidence

To date, only a handful of studies have investigated the relationship between frontal alpha asymmetry and stress-dependent cortisol. Among these few studies, two experiments found that cortisol levels were positively associated with the level of right frontal activation (Kalin, Larson, Shelton, & Davidson, 1998; Tops et al., 2005). However, these studies were not without limitations. For example, a study from Kalin et al. (1998) was conducted with rhesus monkeys and is thus relatively inconclusive for humans. A study from Tops et al. (2005) relied on eleven and female participants only.

In contrast to the aforementioned studies, Brouwer, Neerincx, Kallen, van der Leer, and ten Brinke (2011) reported that stress-contingent cortisol release was related to left frontal activity. They induced stress by a virtual reality environment where participants were exposed to a bomb explosion site. Participants showed significant increases in left frontal activation (F4-F3). Cortisol levels were significantly increased after stress exposure as compared to baseline measurement. Additionally, higher cortisol levels were associated with higher left frontal activation. Similarly, using a within-subjects design, Tops, van Peer, Wester, Wijers, and Korf (2006) found that the administration of cortisol (35 mg) vs. placebo led to an increase in left frontal activation in the cortisol but not in the placebo condition. These results fit with previous findings of a behavioral study (Tops, Wijers, Koch, & Korf, 2006), showing a left hemispace neglect after cortisol administration, probably due to decreased right hemispheric activity, as argued by the authors. Unfortunately, all of these studies were based on relatively small sample sizes (respective Ns =9, 8, and 16). In conclusion, although the literature is mixed, the evidence mostly favors a positive relationship between HPA activity and left frontal cortex activity.

Personality Differences

One issue contributing to the inconsistent literature is the possibility that the relationship between HPA system activity and frontal alpha asymmetries is moderated by personality differences. Research over the past two decades has repeatedly demonstrated that cortisol responses to stress and demanding situations vary with personality traits linked to the ability to regulate emotions and to cope with stress (Kudielka, Hellhammer, & Wüst, 2009, for a review). For example, pronounced cortisol reactions have been found to be associated with low self-esteem, low subjective controllability beliefs (Pruessner et al., 2005; Pruessner, Hellhammer, & Kirschbaum, 1999), and high attachment anxiety (Quirin, Pruessner, & Kuhl, 2008).

Individual differences in ERA are thus a prime candidate to moderate the relationship between frontal asymmetry and the cortisol response to stress. ERA refers to the ability to regulate emotions once aroused rather than to emotion and stress generation, i.e. the sensitivity with which an individual initially reacts to an emotionally arousing situation (Gross, 1999; Kuhl & Koole, 2004). Additionally, ERA influences the continuation and thus the duration of a stress reaction (Gross, 1999; Koole, 2009), Therefore, cortisol responses to social stressors may be modulated by ERA.

A construct that lies at the core of individual differences in ERA is action orientation (AO; Kuhl, 1994a). AO refers to the efficiency with which individuals cope with initial affective responses, i.e. to the ability to disengage from threatening or demanding stressors and, accordingly, to remain functional in the context of upcoming tasks by maintaining cognitive control. By contrast, individuals with low AO (or state orientation) show a tendency to dwell on novel, stressful experiences because they suffer difficulties integrating them in existing cognitive-emotional working models (Kuhl, 2000), a process that has been linked to the left (inferior) frontal cortex activity (Tops et al., 2010). This state-oriented type of processing (Kuhl, 1994) is typically accompanied by negative emotions such as - in the case of social demands – shame, guilt, or embarrassment, which have been linked to left frontal cortex activation (Cope et al., 2010; Finger et al., 2006; Michl et al., 2014).

For example, Jostmann and Koole (2007) reported that under conditions of high but not low demand individuals with high (but not low) levels of AO showed increased cognitive control (for reviews, see Jostmann & Koole, 2010; Koole, Jostmann, Kazén, Baumann, & Kuhl, under review). Likewise, Koole and Jostmann (2004) demonstrated that individuals with high but not low AO were able to disengage from negative stimuli after being stressed by social demands but not when relaxed. Quirin et al. (2011) investigated the relationship between AO and cortisol response to a powerful social stressor, the Trier Social Stress Task (TSST). They found that participants with low AO showed significantly higher cortisol responses to the TSST than participants with high AO. This suggests that individuals with low levels of ERA in terms of low AO show increased cortisol responsivity to social evaluative stress.

Present Research and Hypotheses

The present study investigates the relationship between alpha asymmetries and the cortisol stress reaction, as well as the moderating influence of individual differences in ERA. Specifically, we assessed both saliva cortisol and EEG before and after participants completed the TSST and examined their relationship as a function of ERA. To increase statistical power we relied on a sample size larger than in previous studies on the relation between stress-related frontal asymmetry and cortisol (e.g. Brouwer et al., 2011; Tops, van Peer, et al., 2006).

Based on previous literature on the role of the left frontal cortex in rumination, anxious apprehension, embarrassment, shame and guilt (Engels et al., 2007; Michl et al., 2014; Tops et al., 2010; see also Tops (2014), for a review), as well as on preliminary evidence of a direct relationship between frontal asymmetry and cortisol, we expected that the social evaluative threat as elicited by the TSST would induce a shift in relative left frontal activity. Moreover, because recent evidence suggests a relationship between ERA and stress reaction on the one hand as well as between stress and lateralized brain activation on the other hand, the present study aims at investigating the moderating effect of ERA as indicated by high AO on the direct relationship between the cortisol stress response and hemispheric asymmetries. We hypothesize that the left hemispheric shift is pronounced for participants with low ERA as indicated by low levels of AO (Kuhl, 1994a), because they typically suffer difficulties integrating representations of stressful experiences, such as the TSST, in existing cognitive-emotional schemata as supported by the left (inferior) frontal cortex.

Method

Sample and Procedure

Forty-nine participants (32 female) with a mean age of 22.48 years (SD=3.33) were recruited by an experimenter via flyers and postings and received 15 € or course credit for participation in the study. Participants were informed about the EEG procedure and gave written consent to participate. All experimental sessions started between 1200 h and 1500 h and lasted for approximately 2.5 hours. In a first session, participants filled out a battery of measures that included the action orientation scale and, in addition, the BIS / BAS scales. Individual appointments were made for a second session taking place about one week later, in which resting EEG was recorded by two experimenters while the participant sat in a comfortable chair. Resting state EEG was recorded at two times during the session, directly before the preparation phase of the stress test (t1) and immediately after the stress test (t2). EEG was recorded in occasions of eight 1-min resting periods, where four occasions were recorded with eyes open and four with eyes closed. The measurements were counterbalanced across participants according to one of two sequences of eyes open (O) and eyes closed (C) conditions (O-C-C-O-C-O-O-C or C-O-O-C-O-C-C-O). Participants were informed via a recorded voice when to open or close their eyes.

EEG Assessment

EEG was recorded with a stretchable electrocap (Brain Cap; brand Easy Cap) according to the International 10-20% system (Jasper, 1958) from 29 electrode sites. The recordings were made by an integrated ground (FCZ) and a reference electrode close to the vertex. Electro-oculogram was recorded to control for artifacts due to eye movements. After the scalp under the electrodes had been cleaned with alcohol, an abrasive mild gel was used to reduce impedances. All electrode-impedances were below 5 kΩ and homologous sites were within 1 kΩ of each other. EEG was recorded with the Brain Amp Standard (brand Brain Products GmbH). Data were digitized on a computer with a sampling rate of 500 Hz.

All off-line procedures were conducted using EEGLAB (Delorme & Makeig, 2004). EEG raw data was re-referenced to TP9 and TP10 mastoid electrodes. Artefacts due to eye-movements and blinks were reduced by a blind source separation algorithm (Gómez-Herrero, 2007). Artefact-reduced one minute epochs were segmented in periods of 2 s and were extracted through a Hamming Window. Consecutive epochs had a 75% overlap to minimize data loss due to windowing. Epochs were automatically rejected if the amplitude exceeded ± 75 µV. For remaining epochs a 30 Hz low-pass filter was applied. Resulting data were zero padded and submitted to a fast Fourier transformation to generate the spectral power (μV^2) with a resolution of 0.488 Hz. Power values within the alpha band (8–13 Hz) were averaged across all epochs. Power values were log-transformed to obtain normalized values (Allen, Coan, et al., 2004). Because alpha power in the EEG is inversely related to measures of cortical activity (e.g. Cook et al., 1998), lower levels of alpha power indicate higher levels of activity.

Asymmetry indices for each one-minute period were calculated by subtracting ln alpha frequency of left electrode sites from ln alpha frequency of homologous sites of the right hemisphere (e.g., F4-F3, F8-F7) with higher scores indicating a relatively stronger left-sided activation. Cronbach's alpha coefficients of the asymmetry indices for homologous electrode sites from the eight time periods ranged from .70 to .93.

Stress Induction

In our experiment, we used a public-speaking task variant based on the TSST, because fear of social evaluation has been identified as a crucial determinant of the cortisol stress response (for a review, see Dickerson & Kemeny, 2004). This standardized public speaking paradigm includes a 5 min simulation of a job interview and a 5 min arithmetic calculations task in front of an audience. In contrast to the original TSST, the auditorium was replaced by a video camera in the present study. Participants' speeches were recorded, allegedly for later analysis by an expert group (cf. Alexander et al., 2009; Merz, Wolf, & Hennig, 2010; Quirin et al., 2011). It was expected that participants' cortisol response to this task would be less pronounced than the response to the original version. Nevertheless, we chose this version because previous research suggests that relationships between personality and cortisol responses are more likely to be uncovered when moderate rather than intense stressors are used (Dickerson & Kemeny, 2004; Quirin et al., 2011; Quirin et al., 2008). Prior to the beginning of the speech, participants were informed about the upcoming procedure and were given 5 min to prepare for the speech. Specifically, they were allowed to take notes, which, however, were not allowed to be used during the speech itself. Subsequent to the preparation phase, participants stayed seated in the EEG chair while a camera was positioned in front of them.

Cortisol Assessment

Cortisol was measured via saliva samples. Salivary cortisol is considered a reliable and valid measure of unbound plasma cortisol (Vining & McGinley, 1987). We used the Salivette sampling device (Sarstedt, Rommelsdorf, Germany) to obtain 4 saliva samples from each participant during the course of the experiment. Specifically, baseline saliva samples (t1) were collected about 70 min after arrival and directly before the preparation phase (stress onset). Stress dependent cortisol measures were taken 20 min (t2), 45 min (t3) and 60 min (t4) after stress onset. After the experiment, saliva samples were stored at -20 °C until being sent to the biochemical laboratory of the University of Trier where cortisol was analyzed by a time-resolved immunoassay with fluorescence detection (Dressendörfer, Kirschbaum, Rohde, Stahl, & Strasburger, 1992). The intra-assay coefficient of variation was between 4.0% and 6.7%, whereas the corresponding inter-assay coefficients of variation were between 7.1% - 9.0%. The lower detection limit was 0.43 nM.

Measurement of Individual Differences

Emotion Regulation Abilities. We assessed ERA with the demand-related AO scale (AO; Kuhl, 1994a), which refers to the degree to which individuals are able to maintain self-control for energizing and initiating their action steps even under demanding conditions, instead of turning towards anxious apprehension or prospective rumination. Since the preparation phase of a public speaking task, which typically goes with an anxious anticipation of a prospective stressor, strongly contributes to stress-contingent cortisol increase (Engert et al., 2013; Erdmann & Janke, 2002; Erdmann & Voigt, 1995; Juster, Perna, Marin, Sindi, & Lupien, 2012), the demand-related AO scale might constitute a prime individual differences dimension to moderate cortisol effects in response to the TSST (see also Quirin et al., 2011). In this scale, each of the 12 items describes a demanding situation from everyday life. Participants are asked to choose either a high AO or a low AO response that best describes their typical reaction in this situation. An example item is *"When I am getting ready to tackle a difficult problem, (a) it feels like I am facing a big mountain I don't think I can climb (low AO), or (b) I look for a way to approach the problem in a suitable manner (high AO)".* Action-oriented responses were coded as "1" whereas state-oriented responses were coded as "0". Low AO (so-called "state-oriented") individuals show a tendency towards rumination, hesitation and extensive planning before engaging in a task (Kuhl, 1994b; Stiensmeier-Pelster, 1994). Therefore, restricted time allotted for preparation, as it is the case in the TSST, typically induces emotional stress and pressure in low AO individuals (Dibbelt & Kuhl, 1994; Koole & Jostmann, 2004). In the present sample, Cronbach's alpha for the AO scale was .82.

Prior research indicates the AO scale is a sensitive measure of stress-regulation abilities during a variety of demanding (Koole & Jostmann, 2004) or stressful tasks (Baumann, Kaschel, & Kuhl, 2007) including the TSST (Quirin et al., 2011). In contrast to constructs typically associated with stress reactivity, such as behavioral inhibition (Carver &

White, 1994a), AO refers to the individual ability to regulate stress once aroused rather than to reactivity to stress (Baumann et al., 2007; Kuhl, 1981; Quirin et al., 2011). As a measure of ERA, AO has already been found to be associated with elevated levels of cognitive control (Jostmann & Koole, 2007), facilitation of working memory efficiency (Jostmann & Koole, 2006), work performance (Diefendorff, Hall, Lord, & Strean, 2000), and stress-contingent reduced cortisol levels (Quirin et al., 2011).

Behavioral Inhibition and Behavioral Activation. Whereas action orientation refers to abilities in regulating emotions once aroused (e.g. Kuhl, 1994a), individual differences in BIS and BAS refer to a sensitivity of emotional systems, i.e. to the readiness by which punishment-related (negative) or reward-related (positive) emotions become aroused, respectively (Gray, 1987). To control for trait variance in this sensitivity component, we administered the corresponding scales from Carver and White (1994; German version by Hartig & Moosbrugger, 2003). Fifty-eight items measure the three dimensions of trait anxiety and frustration (BIS), drive and pleasure (BAS), and Anger. The scales showed Cronbach‘s alphas between .76 and .88.

Statistical Analyses

Statistical analyses were conducted using SPSS version 19. As a manipulation check, we used a repeated measures MANOVA approach using the four cortisol assessments as within-participants variables. To investigate relationships between cortisol and alpha asymmetries we focused on the midfrontal region at electrode pair F4 and F3 because it has been repeatedly associated with affective responses and personality differences (for a review, see Coan & Allen, 2004b). To investigate relationships between alpha asymmetries at F4-F3 and cortisol stress responses, we conducted three separate multiple block-wise regressions with post-stressor cortisol measures (t2, t3, and t4) as criterion variables. To control for differences in baseline cortisol level at t1 and alpha-asymmetry scores at t1, these predictors were entered as covariates in a first block, and asymmetry scores for the second measurement were entered as predictors in a second block.

To investigate the moderating effect of either AO on the relationship between cortisol and alpha asymmetry scores while controlling for possible influences of BIS and BAS, we examined a multiple block-wise regression model controlling for cortisol at t1, asymmetry at t1 as well as BIS, and BAS in the first step. In the next step we added AO scores and asymmetry at t2. As a last step the interaction term of either AO scores times asymmetry at t2 were entered into the model.

Because highly correlated predictors, such as asymmetry scores, and product terms within a moderator analysis can cause multicollinearity, all predictors were centered at their own mean value (West, Aiken, & Krull, 1996). For all analyses, tolerance values were over and above .74, indicating no severe multicollinearity problems.

Results

BIS (M = 2.61, SD = 0.42), BAS (M = 2.79, SD = 0.46), and AO (M = 5.60, *S*D = 3.34) were all uncorrelated, rs < .15, ps > .30. We found a significant cortisol change over the course of time, Wilk‘s lambda = .60, $F(3,46) = 10.33$, $p < .01$, $\eta_p^2 = .40$ (M_{t1} (SD) = 7.6 (5.5), M_{t2} = 9.0 (4.6), M_{t3} = 10.5 (6.6), M_{t4} = 9.2 (5.8)). The multiple blockwise regression models investigating the influence of alpha-asymmetry scores at t2 on cortisol revealed significant associations with cortisol levels at t2 and t4 (Table 1), and a non-significant association at t3, $\beta = 0.27$, $p = .07$. Thus, higher cortisol levels were associated with higher relative left cortical activation. [1]

To test for the moderating effect of AO in predicting cortisol levels by alpha asymmetry scores, three block-wise regressions were calculated. The moderator analyses for each of the three cortisol measurements yielded significant results (Tables 2, 3, and 4). To investigate the moderating effects more closely, we conducted simple slope analyses. AO scores were first centered by subtracting one standard deviation (high AO) or by adding one standard deviation (low AO) to the mean. Among low AOs there was a significant relation between asymmetry scores and cortisol levels at t2 (Figure 1, $\beta = 0.49$, $p = .005$). No such relation was found among high AO ($\beta = 0.05$, $p = .77$). The same pattern and levels of statistical significance were obtained for cortisol levels at t3 and t4.

Further, we explored if high and low AO participants differed in their cortisol levels for left or right hemispheric activation. There were no differences between high and low AO for high right hemisphere activation (βs < 0.27, *p*s > .11). For left hemispheric activation there was a trend for measurements at t2 and t3 ($p = .09$ and $p = .08$, respectively) and a significant difference at t4 ($\beta = -0.42$, $p = .04$). Specifically, at each of those three points of measurement, low AO was associated with higher left hemispheric activation. Because BIS and BAS scores have been associated with frontal asymmetries in previous studies, especially at F4-F3, we also investigated this relationship in an exploratory manner. There was no significant relationship between asymmetry scores at t1 and BIS or BAS scores (p = .82 and p = .17, respectively) or asymmetry scores at t2 and BIS or BAS (p = .51 and p = .81, respectively).

Variable	B	SEB	β	R^2	ΔR^2
Model 1: Cortisol t2					
Step 1				.49***	
Cortisol t1	0.56	0.09	.69***		
Alpha Asymmetry[1] t1 (F4-F3)	4.55	3.24	.15		
Step 2				.53***	.05*
Alpha Asymmetry[1] t2 (F4-F3)	5.23	2.50	.24*		
Model 2: Cortisol t4					
Step 1				.21**	
Cortisol t1	0.44	.14	.42**		
Alpha Asymmetry[1] t1 (F4-F3)	7.34	5.08	.19		
Step 2				.28**	.07*
Alpha Asymmetry[1] t2 (F4-F3)	7.92	3.93	.29*		

Table 4: ***Blockwise Regression Analysis Summary for Alpha Asymmetry Scores (F4-F3) at t2 Predicting Cortisol at t2 (Model 1) or Cortisol at t4 (Model 2) While Controlling for Alpha Asymmetry Scores (F4-F3) at t1 and Cortisol at t1***

*Notes: A high value of F4 – F3 indicates a higher left activation; Time 1 (t1): before stress induction, t2: 20 min after stress onset, t3: 45 min after stress onset, t4: 60 min after stress onset; N=49; *p < .05; ** p < .01; *** p < .001*

Predictor variable	B	SEB	β	R^2	ΔR^2
Step 1				.49***	
Cortisol t1	.55	.09	.67***		
Alpha Asymmetry t1 (F4-F3)	4.23	3.36	.14		
BIS	-.81	1.16	-.08		
BAS	-.62	1.12	-.06		
Step 2				.54***	.05
Cortisol t1	.57	.09	.69***		
Alpha Asymmetry t1 (F4-F3)	.65	3.69	.02		
BIS	-1.03	1.13	-.10		
BAS	-.72	1.10	-.07		
Alpha Asymmetry t2 (F4-F3)	5.48	2.57	.25*		
AO	-.02	.15	-.02		
Step 3				.59***	.04*
Cortisol t1	.57	.09	.70***		
Alpha Asymmetry t1 (F4-F3)	.92	3.56	.03		
BIS	-1.29	1.10	-.12		
BAS	-.94	1.07	-.09		
Alpha Asymmetry t2 (F4-F3)	5.80	2.48	.27*		
AO	-.08	-14	-.06		
AO X Alpha Asym. t2	-1.45	.71	-.21*		

Table 5: ***Blockwise Regression Analysis Summary for Predicting Cortisol at t2***

*Notes: N= 49; * p < .05; *** p < .001*

Predictor variable	B	SEB	β	R^2	ΔR^2
Step 1				.26**	
Cortisol t1	.52	.16	.44**		
Alpha Asymmetry t1 (F4-F3)	4.14	5.95	.09		
BIS	-.80	2.05	-.05		
BAS	-2.37	1.98	-.16		
Step 2				.32**	.06
Cortisol t1	.55	.16	.46**		
Alpha Asymmetry t1 (F4-F3)	-1.70	6.59	-.04		
BIS	-1.16	2.02	-.07		
BAS	-2.53	1.97	-.17		
Alpha Asymmetry t2 (F4-F3)	8.94	4.58	.28		
AO	-.03	.26	-.02		
Step 3				.39**	.07*
Cortisol t1	.56	.15	.47**		
Alpha Asymmetry t1 (F4-F3)	-1.20	6.33	-.03		
BIS	-1.65	1.95	-.11		
BAS	-2.95	1.90	-.20		
Alpha Asymmetry t2 (F4-F3)	9.55	4.41	.30*		
AO	-.14	.25	-.07		
AO X Alpha Asym. t2	-2.72	1.26	-.27*		

Table 6: ***Blockwise Regression Analysis Summary for Predicting Cortisol at t3***

*Notes: N= 49; * p < .05; *** p < .001*

Predictor variable	B	SEB	β	R^2	ΔR^2
Step 1				.23*	
Cortisol t1	.41	.14	.39**		
Alpha Asymmetry t1 (F4-F3)	6.24	5.25	.16		
BIS	-.58	1.81	-.04		
BAS	-1.79	1.74	-.14		
Step 2				.30*	.07
Cortisol t1	.44	.14	.42**		
Alpha Asymmetry t1 (F4-F3)	.82	5.79	.02		
BIS	-.91	1.77	-.07		
BAS	-1.95	1.73	-.16		
Alpha Asymmetry t2 (F4-F3)	8.28	4.03	.30*		
AO	-.02	.23	-.01		
Step 3				.40**	.10*
Cortisol t1	.45	.13	.43**		
Alpha Asymmetry t1 (F4-F3)	1.33	5.43	.03		
BIS	-1.41	1.67	-.10		
BAS	-2.39	1.63	-.19		
Alpha Asymmetry t2 (F4-F3)	8,91	3.78	.33*		
AO	-.13	.22	-.08		
AO X Alpha Asym. t2	-2.81	1.08	-.33*		

Table 7: ***Blockwise Regression Analysis Summary for Predicting Cortisol at t4***

*Notes: N= 49; * p < .05; *** p < .001*

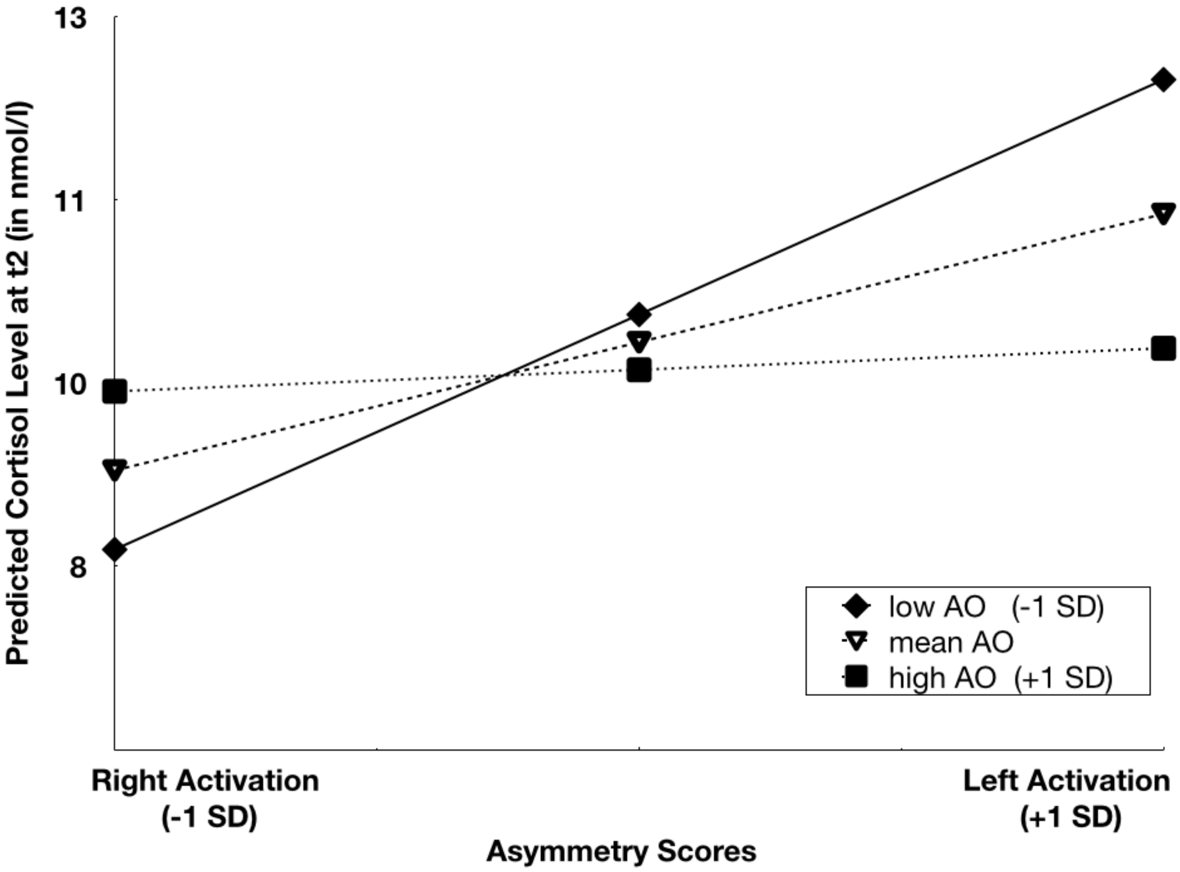

Figure 11: ***Regression Slopes for the Moderating Effect of Action Orientation on the Relationship of Alpha Asymmetries and Cortisol at t2.***

Discussion

The present study investigated the relationship between the cortisol response to public speaking stress and post-experimental frontal alpha asymmetries. Whereas cortisol constitutes a reliable stress marker in response to social evaluation or uncontrollability threat (Dickerson & Kemeny, 2004), frontal alpha asymmetries have also been associated with emotional reactions in the past (Davidson, 2004; Harmon-Jones et al., 2010; Tomarken et al., 1990). We found that higher post-stressor cortisol levels were paralleled by higher frontal alpha asymmetry scores, i.e., left frontal activity. This is consistent with previous findings reporting an association between left frontal activation and anxious apprehension or rumination, as a form of a prolonged reappraisal and the attempt to assimilate stressful experiences encountered in existing cognitive-emotional schemata (Engels et al., 2007; Heller et al., 1997;

Simmons et al., 2013; Tops et al., 2010). Our finding is also in line with a left-lateralization of frontal cortex activity during negative social emotions such as shame and guilt (Compton & Mintzer, 2001; Dickerson et al., 2004; Finger et al., 2006; Michl et al., 2014). Notably, we additionally investigated individual differences in ERA and found that the association between cortisol and left frontal activity was more pronounced for individuals with low ERA.

It is instructive to compare our results to earlier studies on the relationship between cortisol and frontal asymmetry (Brouwer et al., 2011; Kalin et al., 1998; Kang et al., 1991; Lewis, Weekes, & Wang, 2007; Tops, van Peer, et al., 2006). Specifically, whereas Brouwer et al. (2011) as well as Tops, van Peer, et al. (2006) found an association between cortisol increase and left frontal activation, Kalin et al. (1998) contrarily found increased cortisol being related to relatively right frontal asymmetry. Two further studies (Kang et al., 1991; Lewis et al., 2007), however, did not find a significant relationship between the two variables. As such, the present study replicated the findings from Brouwer et al. (2011) as well as Tops, van Peer, et al. (2006) with a considerably larger sample. Moreover, our findings extend those earlier studies by replicating the relationship between left-hemispheric lateralization and cortisol reaction to social stress as induced by the TSST, the most widely applied and the most reliable procedure for the induction of stress-related cortisol changes so far.

How might the inconsistencies reported in the literature be explained? First, the fact that previous studies used divergent methodologies could easily have led to different outcomes. For example, Kalin et al. (1998) only investigated trait-like cortisol level and alpha asymmetries in rhesus monkeys, whereas Brouwer et al. (2011) applied a virtual reality environment to induce stress in humans, while Lewis et al. (2007) investigated the relationship between cortisol and alpha asymmetries during a period of multiple exams, i.e. under a natural stress condition. Therefore, we closely inspected the different experimental settings in order to understand the seemingly contradictory findings. Kalin et al. (1998) as well as Lewis et al. (2007) did not measure acute phasic stress reactions but found a tonic relationship between alpha asymmetries and cortisol level. In contrast, Tops, van Peer, et al. (2006), Brouwer et al. (2011), as well as the present study assessed the association between cortisol and alpha asymmetries either after cortisol injection or directly after an experimental stress induction. The common findings of those studies may thus be attributable to a phasic change towards the left frontal cortex. A preponderance of right cortex activation might be confined to situations involving chronic stressors.

The present findings are compatible with the role of the left inferior frontal cortex in worry and anxious apprehension (Borkovec et al., 1998; W. R. Carter, Johnson, & Borkovec, 1986; Engels et al., 2007; Heller et al., 1997; Simmons et al., 2013). Since the preparatory phase of the TSST strongly contributes to stress-contingent cortisol increases (Engert et al., 2013; Erdmann & Janke, 2002; Erdmann & Voigt, 1995; Juster et al., 2012), they are also compatible with existing evidence of activity of the left frontal cortex in response to worrying about an anticipated public speech (Hofmann et al., 2005).

The present findings might also bear on the question of the efficiency with which the two hemispheres exchange information. Communication between the two hemispheres has in fact been associated with emotion regulation in previous theorizing (Henry, 1993; Kuhl, 2000; Parker & Taylor, 1997). Compatible with this notion, Compton and Mintzer (2001) demonstrated that high worriers show an ineffective interhemispheric coordination. More recent research suggests that the right inferior frontal cortex is implicated in orienting towards and appraising novel experiences (e.g. Ochsner et al., 2012), whereas the left inferior frontal cortex is implicated in reappraising these experiences and integrating them in existing schemata (e.g. Hayes et al., 2010; Tops et al., 2010; Tops et al., 2014). As such, the present finding of an increased relationship between cortisol increase and left frontal activity shift in low ERA individuals might result from or result in impairments of the communication between the frontal lobes of the two hemispheres. Additionally, since the left inferior frontal cortex has been found to be associated with rigidity (e.g. Brown, Acevedo, & Fisher, 2013; Rothemund et al., 2011; Tucker, Luu, & Pribram, 1995), whereas creative flexibility has been found to be associated with right temporo-frontal network activity (Jung-Beeman et al., 2004; Mihov et al., 2010), the difficulty of low AO individuals to initiate new courses of action and flexibly organize them under demanding situations (Koole, Jostmann, & Baumann, 2012; Kuhl, 2000; Kuhl & Beckmann, 1994), might additionally contribute to the present effect.

At least two limitations of the present study should be mentioned. First, we interpreted the present findings in a way that stress-contingent cortisol caused a lateralization of activity towards the left frontal cortex, particularly for low ERA individuals. However, the correlational design of the present study does not allow for a test of the causal direction. As such, it cannot be rule out that frontal activity shifts influenced cortisol release or that our findings were driven by a mutual influence. For example, individuals who may show a tendency towards worry and rumination across the course of the TSST along with left-frontal activation may be less able to adequately cope with stress and thus exhibit a disinhibited cortisol response.

Second, Tops, van Peer, et al. (2006) speculated how environmental and experimental settings could possibly influence the association between hemispheric asymmetry and cortisol level. They reported stronger right hemispheric activity after cortisol administration for non-formal settings but a stronger left hemispheric activity in a formal setting. Our experimental setting was presumably more formal and therefore it cannot be excluded that at least some variance may be explained by the environment. Nevertheless, the environment is not able to explain the moderating effect of interindividual differences in ERA. Therefore it seems plausible that the association found between cortisol level and frontal asymmetry occurs over and above pure environmental influences.

Conclusion

We presented additional evidence for the association between cortisol responses to induced social stress and left frontal activity, which was elevated for individuals low in ERA. As such, considering individual differences in ERA may be necessary when investigating the interplay of neural activation and endocrine responses.

The endeavour to understand is the first and only basis of virtue.

Baruch de Spinoza

Chapter 5

General Discussion

The aim of the present work was to investigate individual differences in motivational processing. More specifically, within the PSI framework, these motivational processes can be linked to different macrosystems (see Figure 1), which in turn are related to lateralized cerebral functions. A detailed analysis of the lateralized functioning of motivational processes can help to understand and disentangle the underlying mechanisms and contribute to the validation of the PSI theory. Therefore, taking cerebral asymmetries as starting point, the motivational processes (i.e. affiliation or action orientation), cognitive functions (i.e. intuition), or physiological reactions can be modeled around them (Figure 1). A variety of different measures have been applied to tackle the research question from different sides. For example, implicit and explicit measures were applied to assess individual differences in personality (e.g. OMT, MET), a behavioral measure to assess cognitive functions (e.g. RAT), resting state EEG and source localization to directly assess cerebral asymmetries, and physiological marker (i.e. salivary cortisol) to assess the stress reaction.

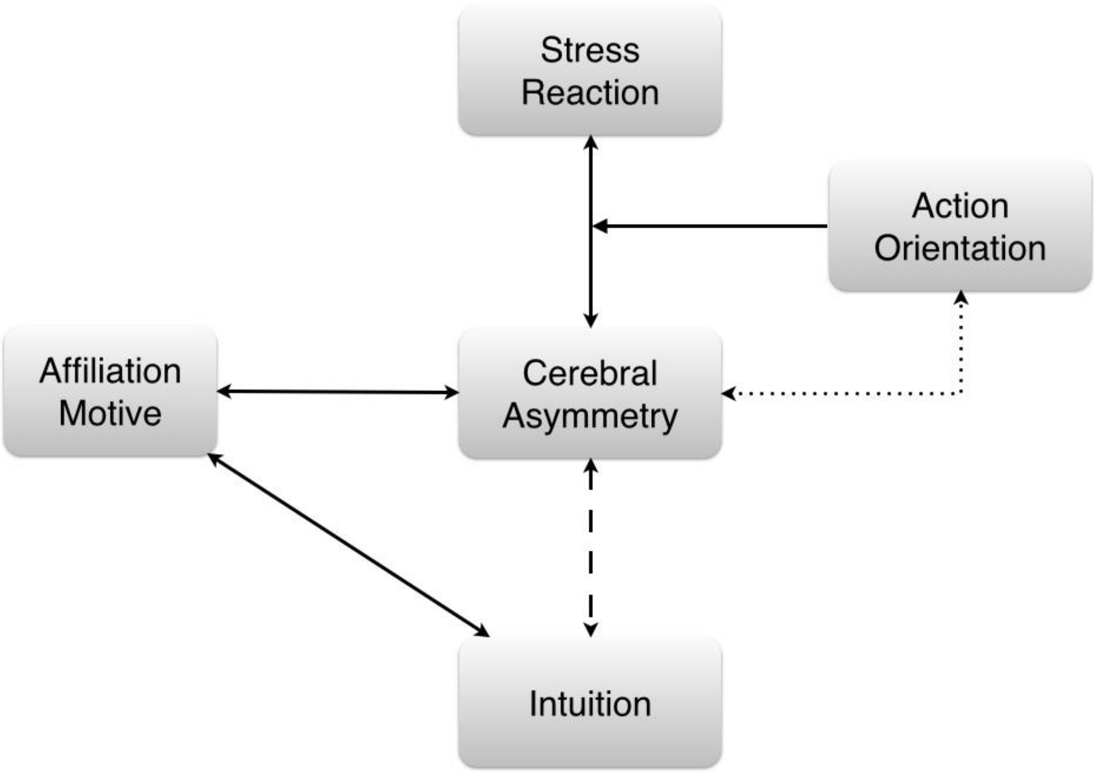

Figure 12: Cerebral Asymmetry and the Interconnection to Different Aspects of Personality
Notes: A Solid Line Indicates a Direct Association, measured in this work; A Dashed Line Indicates an indirect Association, not measured; A Dotted Line Indicates an Assumed Association.

More specifically, each of the three research articles presented throughout chapter 2 to chapter 4 contributes with different approaches to the aforementioned goal and to clarify the connections presented in Figure 10. For example, the first article (chapter 2) covered the association between the affiliation motive and intuition. It has been *directly* shown that trait affiliation motive is associated with intuition, as indicated by a solid line. As indicated by a dashed line, the connection between intuition and cerebral asymmetries has not been measured directly in our research, but former research (for a meta-analysis, see Mihov et al., 2010) shows evidence that this is the case (see a more elaborated discussion about this topic in a following section). Therefore, it can be assumed that affiliation and cerebral asymmetries are somehow related. To investigate this latter assumption *directly*, the second article (chapter 3) measured resting state EEG, or more specifically alpha asymmetries, and again the implicit affiliation motive. The results indicated relative stronger right frontal activity. Furthermore, a source estimation algorithm revealed an area in the right ventromedial PFC as a source for the asymmetry at scalp sites. The third article presented in chapter 4 highlights motivational differences slightly different to the other chapters. It deals with dynamic motivational processes, such as action orientation, and how they moderate the association between cerebral asymmetries and the physiological stress reaction (solid line from action orientation on the connection between cerebral asymmetry and stress reaction in Figure 10). Again, resting state EEG was used, but this time in a pre-post design to catch the dynamic influence of action orientation. Cortisol samples were taken as a marker for the stress.

The author wants to use the following paragraphs of the discussion section to elaborate more on some aspects of the reported findings and associations, which have been a little on the short side in the particular discussion sections due to space limitations or when the argumentation was beyond the scope of the specific publication. Additionally, some more shortcomings, critiques, and possible remedies will be presented. Besides that, the author wants to add some remarks, which will help to (re-)integrate the findings into the PSI framework.

Implicit Affiliation and Intuition

With the first study "Implicit Affiliation Motive Predicts Correct Intuitive Judgments" presented in chapter 2, the author indirectly demonstrated the cerebral lateralization of the implicit affiliation motive. The author used the RAT, which has been associated with a processing advantage for the right hemisphere (e.g. Beeman et al., 1994; Bowden & Beeman, 1998; Bowden & Jung-Beeman, 2003). Participants with a high implicit affiliation motive showed a clear advantage in solving the remote associates. The results remained significant when controlling for other variables such as state and trait positive affect, or extraversion. No other implicit or explicit motive measure correlated with the RAT.

Therefore, it was concluded that the affiliation motive might somehow be more related to a right hemispheric processing. But what if the RAT is not related to right hemispheric processing at all? For example, Dietrich and Kanso (2010) reviewed EEG, ERP, and neuroimaging studies examining a relationship between cortical activity and three different concepts associated with creativity: *divergent thinking*, *artistic creativity,* and *insight*. RAT in turn can be subsumed under the categories divergent thinking or insight, depending on the instructions, if the solution word has to be named explicitly. For divergent thinking, the results from EEG and neuroimaging studies, which Dietrich and Kanso (2010) report, are highly variegated, showing only a diffuse prefrontal activation for the former and additional motor cortex and tempoparietal activations. For insight, the results are more consistent, indicating activation patterns for the anterior cingulate cortex and prefrontal areas. But taken together, they conclude that creativity cannot be associated with a specific brain region or with the right hemisphere in particular. It needs to be subdivided into different types to be meaningfully associated with specific neurocognitive processes.

The conclusion Dietrich and Kanso draw from their review sounds convincing, but seems to be not thought out consequently. There is a huge methodological variance within each of the investigated categories divergent thinking, artistic creativity, and insight. For example, they mention eleven experiments using the RAT or variants thereof, investigating divergent thinking or insight. Six of them report a direct association between right hemispheric activation and RAT/insight performance, and two additional experiments report a higher interhemispheric coupling being correlated with RAT/insight performance. Their conclusion that there is no association between the right hemisphere and insight or declarative thinking seems a bit hasty, when the fact is considered that the different studies also put their foci on different aspects of the EEG analysis. Some of them concentrated on the alpha frequency spectrum (e.g. Jung-Beeman et al., 2004), others on the beta or gamma band (e.g. Kounios et al., 2006). Some were interested in the amplitudes, some in the total time of alpha spectrum (e.g. Martindale, Hines, Mitchell, & Covello, 1984), others measured interhemispheric coupling (e.g. Razumnikova, 2005) and yet others investigated ERPs (e.g. Qiu et al., 2008) or even fMRI (e.g. Jung-Beeman et al., 2004) and PET (e.g. Bechtereva et al., 2004) data. As can be seen, even if one can break down on the least common nominator with regards to contents, namely the use of one specific creativity measure (RAT or insight in general), it reveals a huge variance of analysis methods. It would be more than odd, if all of the analyzed dependent measures would reveal the same outcome. Additionally, Dietrich and Kanso (2010) focused in their review paper only on EEG and neuroimaging studies and so their conclusion is solely based on these results.

By contrast, Mihov et al. (2010) conducted a meta-analytical integration of all available literature investigating brain specialization and creativity. Their research covered different measurement techniques for assessing lateralization (e.g. behavioral and imaging techniques), which seems to draw a more complete picture. Their results strongly support the notion of a right hemispheric superiority in creative thinking with an effect size for *Cramer's*

V = .432. Therefore, despite some critical notions by Dietrich and Kanso (2010), creativity and specifically the RAT, seem to be appropriate markers to indirectly assess lateralized brain functions.

Taken together, the data show an advantage for people with a pronounced affiliation motive in solving remote associates, which is an affirmation for the direct association between affiliation and intuition as depicted on the left side of Figure 10. Moreover, it provides additional evidence for the close connection between the extension memory and social motives in general (see also Figure 1) and more specifically with the affiliation, as described by Kuhl (2005a).

Frontal Asymmetries and Affiliation

Compatible with the results from the first study, the second study demonstrated an association between the implicit affiliation motive and right cerebral activity measured with resting state EEG. A closer inspection of the data revealed that the asymmetry between right and left hemispheric activity originated from participants with a low affiliation motive, showing a decreased activity on the right side. A source estimation of the activity pattern at scalp sites indicated a lower activation in the right ventromedial PFC for low affiliation participants. Basing on the results from the first experiment and the literature investigating lateralization of the RAT, we would have expected a higher activation of the right hemisphere for participants with a high implicit affiliation motive. But how can this “underactivation” in low affiliation participants be interpreted?

The ventromedial PFC has repeatedly been found to be part of “default mode network” (DMN; Raichle et al., 2001) of the brain, which refers to an anatomically defined brain system preferentially activated during resting states in which individuals do not direct their attention towards external stimulation or tasks (for a review, see Buckner, Andrews-Hanna, & Schacter, 2008). In turn, alpha oscillations are negatively correlated with brain activity or the BOLD signal in fMRI (Laufs et al., 2003). Typically, the DMN becomes activated when participants are not actively engaged in cognitive task and when distracting external stimuli are absent, which is the case for the resting-state condition used for the assessment of alpha asymmetries. Therefore, this absence of tasks and distractors may foster internally directed and self-referential cognitions (Tops et al., 2014). The results of the present work can be interpreted that participants with a low affiliation motive tend to show a less pronounced self-referential cognitions, which are necessary for a fruitful interpersonal exchange (Kuhl, 2005a). In turn, a better pre-activation seems to foster the fast recall of intuitive routines to interact with others (Kuhl, 2001), accompanied by a more global thinking style and creative thinking (Mihov et al., 2010). Therefore, it seems not to be a “more” which enables the high affiliation participants to perform better, but a “less” of pre-activation for the low affiliation participants to perform worse.

Following (Coan & Allen, 2004a), it might be hypothesized that associations of motivational variables with baseline cortical asymmetries are weak in general, but can substantially be strengthened if the corresponding motive is actually stimulated. Therefore, future research should take also into account the findings that resting frontal asymmetry is also influenced by situation variance (Coan & Allen, 2003b; P. Gable & Harmon-Jones, 2008). In fact, we found a small, albeit stable correlation between the trait measure and baseline activity. The association between affiliation and right frontal activation could be strengthened by combining trait and state motivational processes. For example, state affiliation motivation could be experimentally manipulated by affiliation-laden pictures or an imagery task. It can be expected that high trait affiliation participants in the high state affiliation group will show the strongest activation in the right PFC, whereas low trait affiliation participants in the low state group will show the lowest activation.

Another method to assess the contributions of state and trait variance would be to assess several resting state measurements over a course of time. Although being a typical standard (Coan & Allen, 2003b; Wacker et al., 2010), the application of a one-occasion resting EEG measurement does not allow controlling for state variance, which would contribute to the measurement error in the present case. As such, in order to potentially strengthen the size of the effect at most, future research should combine several resting-state measurements, as well as an experimental manipulation. With such an approach, the contributions of implicit motives to the DMN could also be clarified.

Another perspective on the role of affiliation motive in the context of BIS and BAS (Gray, 1987) or the approach/avoidance model (Harmon-Jones et al., 2010) fell short in the discussion of the particular article. In these models, BAS or approach motivation are typically associated with left lateralized activity, whereas BIS or avoidance are associated with right lateralized activity. At first glance, the finding that the implicit affiliation motive is correlated with activity in the right ventromedial PFC seems to contradict BIS/BAS or the approach/avoidance models, when we assume that affiliation is simply an approach related process. One the one hand, the right hemisphere seems to be more involved in self-control and inhibition, but on the other hand evidence suggests that exactly these processes are needed for fruitful social interactions (for a review, see Hecht, 2014). It seems as if positive prosocial behavior requires the inhibition of one's own needs, goals and desires. For example, high self-control and patience is associated with cooperation and helping of others (Curry, Price, & Price, 2008; Fehr & Leibbrandt, 2011), donation and charity (Martinsson, Myrseth, & Wollbrant, 2012), forgiving misbehavior (Balliet, Li, & Joireman, 2011), and a lower exploitation of public resources (Fehr & Leibbrandt, 2011). Furthermore, Blackhart and colleagues (2011) showed that trait self-control was positively correlated with feelings of belonging and perceived acceptance by family and friends. From this point of view, a high affiliation motive may be seen as the ability to postpone and inhibit own needs and goals to serve social purposes.

Within the PSI theory, affiliation can also be seen as a form of avoidance behavior (Kuhl, 2001). Avoidance can be understood in a sense of avoiding the separation of others. In the original version of the OMT, five different levels of affiliation can be distinguished in accordance to the functioning and activation of different affects (e.g. A+ or A-) and therefore different macrosystems. Scheffer et al. (2003) for example, investigated the relationship between the implicit affiliation motive and coherency of the nuclear family. They found that especially the fourth level (A4), which is associated with inhibited positive affect, was related to coherency. Participants who characterized their family structure as aloof and distant showed a significantly higher implicit affiliation motive, as participants who characterized their family structure as cohesive. One could argue that participants from aloof families try or "wish" to avoid these strong hierarchical structures, which in turn leads to an elevated affiliation. To put it differently, a frustrated affiliation motive during early childhood may lead to an increased need to avoid separation during adulthood. The author was not able to test this hypothesis in the present data, because the internal consistency was too bad for the separated levels of the motives. Therefore, it can only be speculated that especially level A4 contributed to the reported effect. But for future research, separating the different motive levels seems to be promising approach to gain deeper insight of the contributions of each affect-motive combination to lateralized brain activity.

Left Hemisphere, Cortisol, and Motivation

The fourth chapter goes beyond the measure of static processes such as implicit motives and resting state EEG measurement only under baseline conditions. The dynamic relations between personality differences, hemispheric activation and stress reaction under demanding conditions was in the scope of the paper “Emotion Regulation Abilities Moderate the Relationship Between Left Frontal Brain Activity and Cortisol Release After Social Stress“. Action and state orientation are playing a major role within the PSI theory to explain the self-regulated inhibition and activation of the different macrosystems. Especially the intention memory gets activated, when automatic action routines from the intuitive behavior control system are not sufficient to master a challenging situation (Kuhl, 2000, 2001). In PSI theory, a successful accomplishment is characterized by a dynamic shift from intention memory to intuitive behavior control, to put the intentions into action. Since intention memory and intuitive behavior control are associated with left and right hemispheric processing, respectively, it is the interhemispheric coordination (Compton & Mintzer, 2001) of macrosystems, which enables a successful accomplishment. AO people are characterized by the ability to establish this interhemispheric exchange in a self-regulated manner, i.e. to upregulate positive affect. By contrast, SO people need to rely on external feed charge of positive affect, to inhibit the inhibition between intention memory and intuitive behavior control. In the present study, the results indicate that especially SO participants show the strongest cortisol stress reaction, when this is accompanied by an elevated activation of the left hemisphere. This could be an indicator for a prolonged activation or an “overactivation” of the IM. It seems as if at least some of the SO participants were “stuck” within the IM, causing a physiological overreaction, i.e. stress. Contrary, there was no effect for AO on the association between lateralized activation a cortisol reaction. This may be interpreted in terms of a successful interhemispheric coordination.

But how can the present results contribute to the current field of emotion and emotion regulation? What is the difference to other findings showing a lateralization for processes or traits like BIS and BAS (Harmon-Jones et al., 2010; Wacker et al., 2010)? With respect to hemisphere asymmetries, a large body of literature suggests a relationship between personality traits and frontal asymmetries in the EEG alpha band spectrum (Coan & Allen, 2004a). For example, BAS activity has been conceptualized as a sensitivity for conditioned reward, non-punishment, or escape from punishment (Gray, 1987), or for positive affect (Carver & White, 1994b), whereas BIS has been conceptualized as a sensitivity for signals of punishment, novelty, or fear stimuli (Gray, 1987), or for negative affect (Carver & White, 1994b).

Wacker et al. (2010) for example used a meta-analytical strategy to investigate the quite established theory claim of a lateralized BAS functioning. Overall, they found no or only a very weak association. In contrast to the widely accepted model, where BAS should be associated with left hemispheric alpha activity, they demonstrated that this relationship is far away from being consistent. The authors conclude that future research is needed to explain the relationship between traits and frontal asymmetries, and that there are possible, still not identified moderator variables. Therefore, it seems necessary to determine under which circumstances personality differences should occur and therefore influence behavior and brain activity. The study presented in chapter four tackled this problem by investigating personality differences in situations where they are more likely to emerge. Especially individual differences in ERA (e.g. AO, Kuhl, 1994a) might be a more appropriate measure than BIS or BAS, because ERA refers to the ability to *regulate* emotions once aroused rather than to emotional *sensitivity*. Unlike such primary appraisal processes (e.g. BIS, BAS), regulatory processes (e.g. AO) should emerge some time after the onset of an induced affect. Therefore, differences should be the more pronounced with increasing interval since the experimental manipulation.

It is necessary to distinguish between sensitivity (i.e., onset gradient) and regulation of affect (i.e., offset gradient) because disadvantageous health outcomes typically result from a prolonged duration of dysregulated cortisol levels, which is described by the gradient of the termination (offset) of emotional arousal (McEwen, 2008). High sensitivity to (i.e., steep onset gradient or high primary appraisal of) negative affect does not increase (and even decreases) the risk of psychosomatic symptoms, when negative affect can swiftly be downregulated, that is when secondary appraisal (offset of affect) is effective (Baumann et al., 2007). Many studies have shown that high sensitivity or vulnerability toward a given class of symptoms (e.g., anxiety, depression or hyperactivity) can even protect against those symptoms, when people having a psychological, physiological or genetic vulnerability if they have been exposed to benign conditions (e.g., in childhood or therapy) supporting the development of efficient secondary coping (Belsky & Pluess, 2009). Therefore, the stress reaction should depend more on the regulatory processes, especially with increasing temporal interval from the stress procedure. To put it differently, individual differences in ERA determine the duration and perseverance of an emotional reaction. Because ERA is not needed unless individuals are exposed to stress, individual differences in ERA should predict emotional responses and cognitive performance under conditions of stress rather than under baseline conditions. In accordance with this prediction, Jostmann and Koole (2007) reported that under conditions of high but not low demand, individuals with high (but not low) levels of AO showed increased cognitive control (for reviews, see Jostmann & Koole, 2010; Koole et al., under review).

Because BIS and BAS measures are more closely associated with a sensitivity for (primary appraisal of) positive or negative affect, respectively, it comes as no surprise that BIS and BAS measures do not have any significant effect on cortisol levels and lateralized brain activation in the regression models (Tables 5-7). In contrast, effects for (secondary) regulatory processes could be identified; AO moderated the effect of asymmetries on the cortisol stress reaction. Additionally, on a descriptive level the difference between AO and SO was even larger for the last measurement time (t4). This underscores the ability of the AO scale to measure stress regulatory processes instead of a general sensitivity and reactivity to stressful events (Baumann et al., 2007; Koole & Jostmann, 2004; Kuhl, 1981; Quirin et al., 2011).

Additional analyses of the present data did not reveal any relationship between BIS or BAS scores and alpha asymmetries, which is in line with the meta-analysis from Wacker et al. (2010). According to the view presented here, measures related to the onset gradient of positive or negative affects (e.g., BAS and BIS) are not consistently related to frontal asymmetries, because activation of frontal emotion-sensitive brain areas are a function of the duration of positive or negative emotional states (i.e., their offset gradient) more than being a function of their onset gradient. These findings are consistent with the theoretical claim that individual differences in action vs. state orientation are related to regulatory processes, which determine the duration of emotional states once aroused.

From the present data, connection between action orientation and hemispheric asymmetries remains somewhat unclear (Figure 10, dotted line). According to PSI, AO people are characterized by a better access to the extension memory, which in turn is associated with right hemispheric functioning. On the other hand, it is the dynamic exchange between the extension memory and the other three macrosystems and therefore the shift between the hemispheres, which enables AO to be capable of acting even under difficult and demanding conditions. In the present sample there was no association between AO and resting state alpha asymmetry scores under baseline condition or after stress induction. But because alpha asymmetry scores are a rather coarse measurement, aggregating power values over a time of eight minutes, only relative strong accentuations to one or the other hemisphere can be detected. Fast dynamic changes from left to right side, which may be expected at least for AO participants, are not detectable. For this purpose, different paradigms and analysis methods need to be developed. One approach in this direction has been made by Allen and Cohen (2010), who introduced a novel metric of “transient burst asymmetries” calculated from resting state EEG. They attempt to provide a more in-depth neurodynamical understanding of recurrent endogenous cortical processes during resting state. Although this seems to be a very promising approach, it is still in the fledgling stages and additional research is needed. With the coarse alpha asymmetry measure at hand, it may be speculated that the present results favor to some degree the assumption of a dynamic interhemispheric exchange. For future projects, an analysis of transient burst asymmetries could be fruitful to confirm this assumption.

At least some remarks should be made on the association of SO and psychological disorders. In PSI theory, major depressive disorder (MDD; American Psychiatric Association, 2000) and SO, especially SOD, are thought to be very similar constructs (Kuhl, 2001). SOD seemed to be a precursor or at least a non-pathological variant of MDD. Both phenomena are characterized by a depressed, worrying mood, and a diminished activation level (American Psychiatric Association, 2000; Kuhl, 2001). But in contrast to the present findings, MDD has been repeatedly associated with right hemispheric physiological hyperactivation (e.g. Davidson, Pizzagalli, Nitschke, & Putnam, 2002), while it’s functional activity seems to be reduced (for a review see also Rotenberg, 2004). It may be assumed that MDD represents qualitatively another functional deficit, which is phenotypically similar to SOD. Further research is needed to disentangle the structural and functional differences between SOD and MDD.

A clear advantage of the present study should not remain unmentioned. In our study we used a widely accepted, very often applied, and quite naturalistic stress induction (Dickerson & Kemeny, 2004), as compared to other studies (e.g. Brouwer et al., 2011). This allows a comparison of the results to former experiments, with regard to the cortisol reaction, as well as to future research. It is only possible to interpret con- and divergent results, if external conditions are held constant. This is especially true when assessing individual differences. Otherwise different outcomes are not clearly attributable to individual or environmental variables.

Final Remarks

Throughout the previous chapter, the author presented different facets of motivation and motivational processes and how they are related, entangled, and connected with seemingly disconnected aspects like cognitive processes, cerebral asymmetries, humoral as well as behavioral reactions. The vast majority of contemporary research focuses on individual aspects and thus misses to take into account their complex interplay. With the present work the author strived to shed some light on this complex manner. Therefore, I would like to close this dissertation with the motto from Julius Kuhl's book "Motivation und Persönlichkeit", which accompanied and affected me since the first semester of my academic studies:

"Life becomes simple when we accept its complexities."

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Appendix A: Questionnaires

OMT

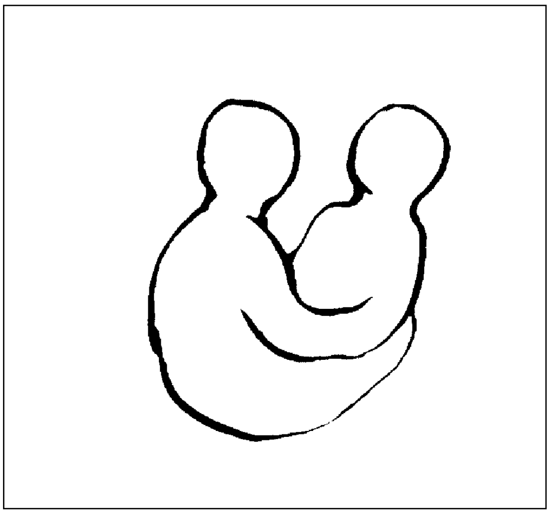
Im folgenden sehen Sie einige Bilder. Jede Bildsituation soll eine alltägliche Lebenssituation darstellen.

Bitte sehen Sie sich jedes Bild zunächst genau an und überlegen Sie sich dann eine kurze **Geschichte** oder eine **Szene**, die die dargestellte Situation näher beschreibt. Der Inhalt der Geschichte bleibt ganz Ihnen überlassen; es gibt keine richtigen oder falschen Geschichten. Lassen Sie Ihrer **Phantasie** freien lauf, die Originalität der Geschichte spielt keine Rolle.

Eine der Personen auf dem Bild soll darin die **Hauptrolle** spielen; kennzeichnen Sie diese Person bitte mit einem **Kreuz**. Sie müssen Ihre Geschichte nicht aufschreiben, sondern nur jeweils die Fragen, die Sie neben jedem Bild finden und die sich auf Ihre Hauptperson beziehen, beantworten.

Beginnen Sie bitte mit Bild 1 und gehen Sie dann der Reihe nach vor.

1)



Was ist für die Person in dieser Situation wichtig und was tut sie?

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Wie fühlt sich die Person?

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Warum fühlt sich die Person so?

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Wie geht die Geschichte aus?

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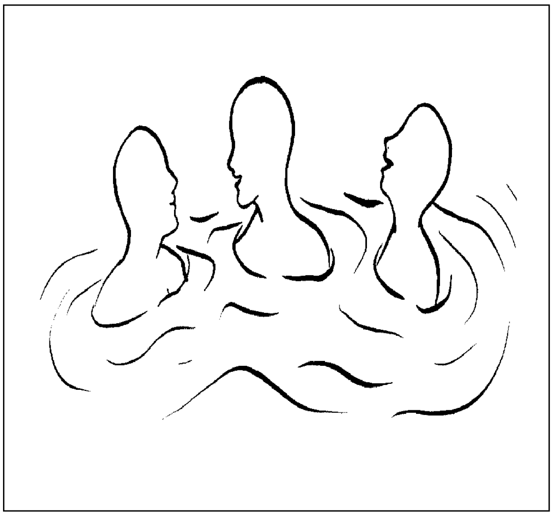
2)



Was ist für die Person in dieser Situation wichtig und was tut sie?

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Wie fühlt sich die Person?

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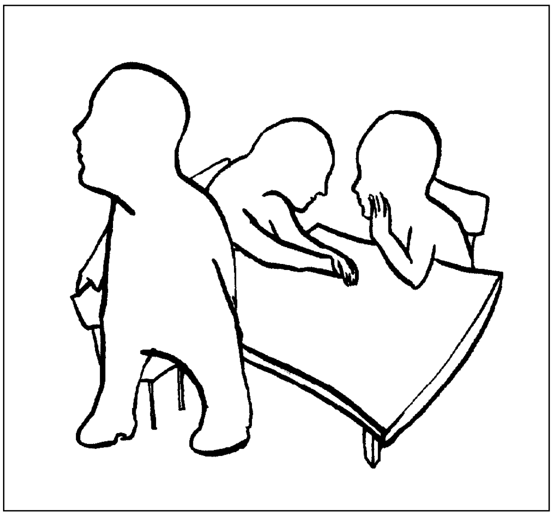

Was ist für die Person in dieser Situation wichtig und was tut sie?

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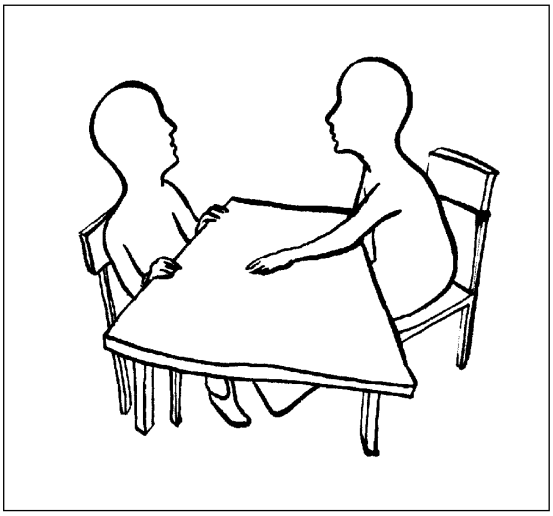

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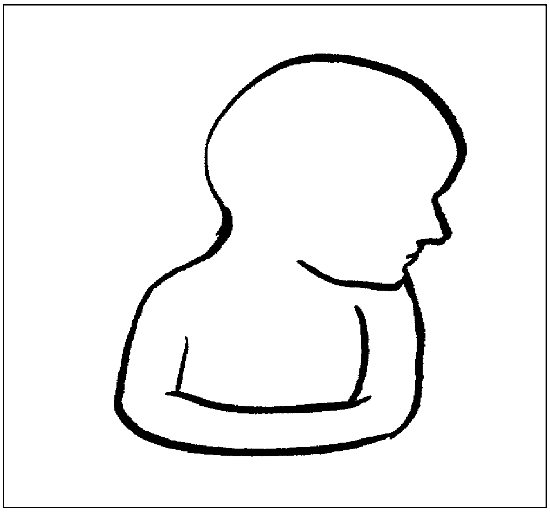

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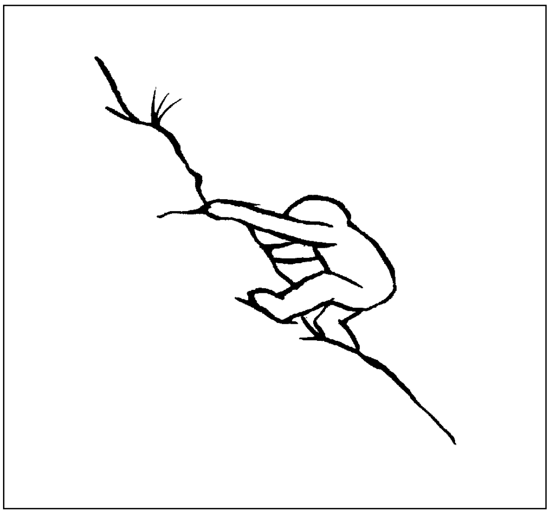

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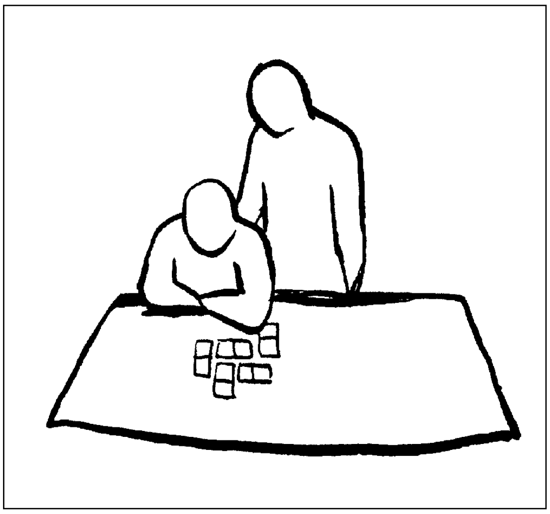

Was ist für die Person in dieser Situation wichtig und was tut sie?

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Warum fühlt sich die Person so?

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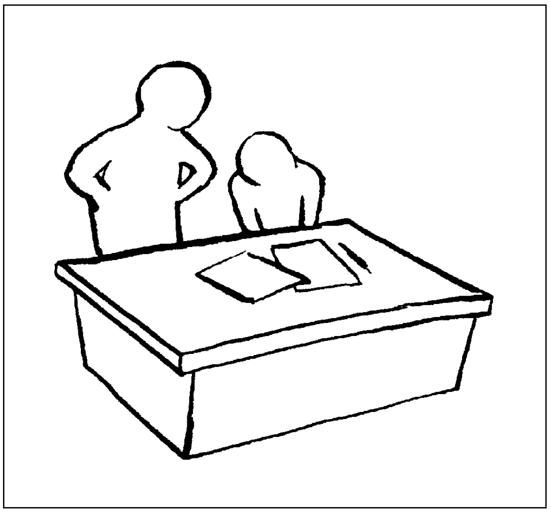

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Warum fühlt sich die Person so?

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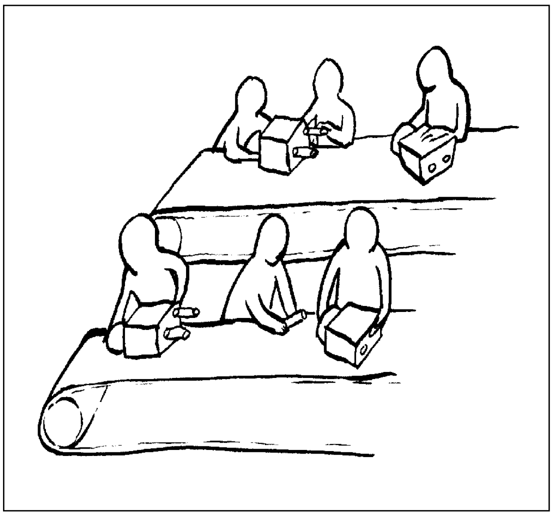

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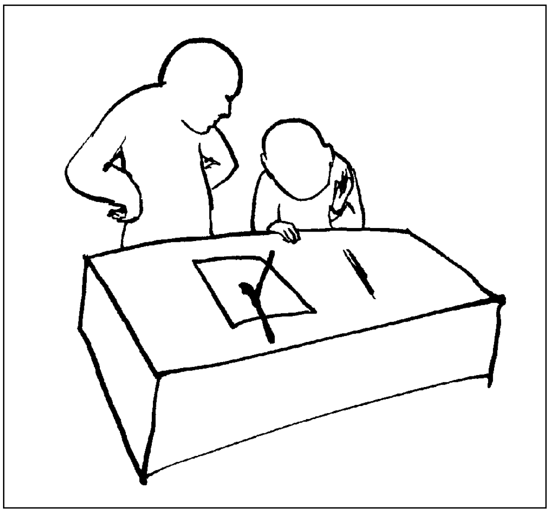

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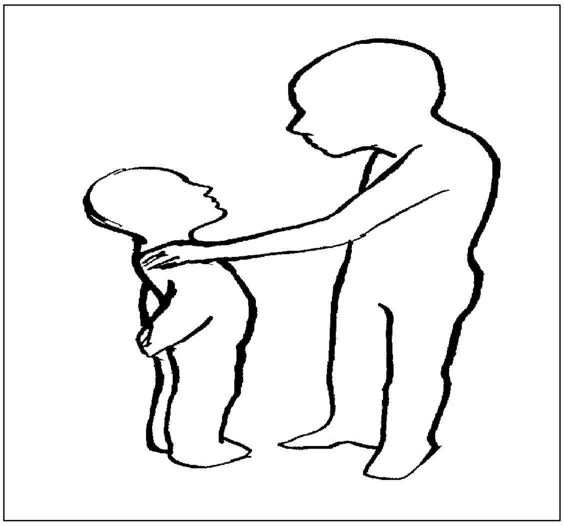
Warum fühlt sich die Person so?

Wie geht die Geschichte aus?

11)



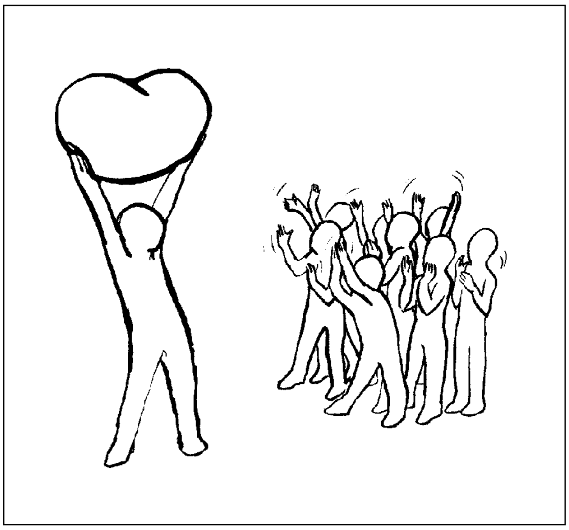
Was ist für die Person in dieser Situation wichtig und was tut sie?

Wie fühlt sich die Person?

Warum fühlt sich die Person so?

Wie geht die Geschichte aus?

12)



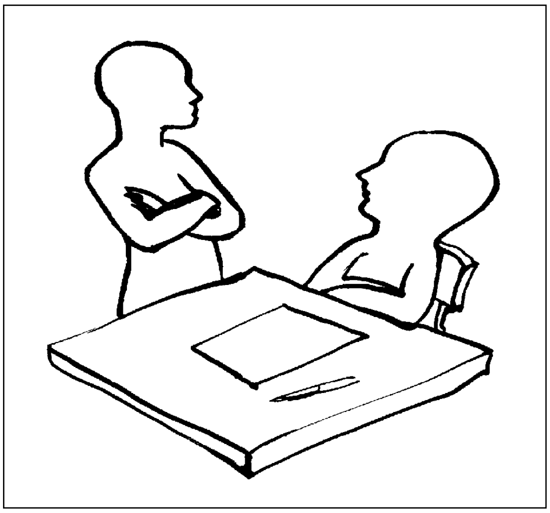
Was ist für die Person in dieser Situation wichtig und was tut sie?

Wie fühlt sich die Person?

Warum fühlt sich die Person so?

Wie geht die Geschichte aus?

13)



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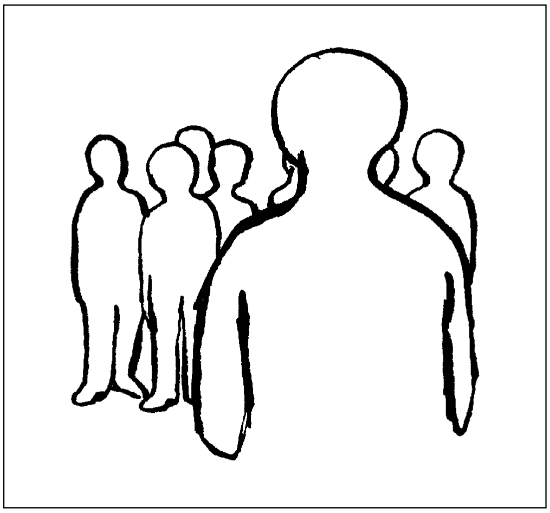

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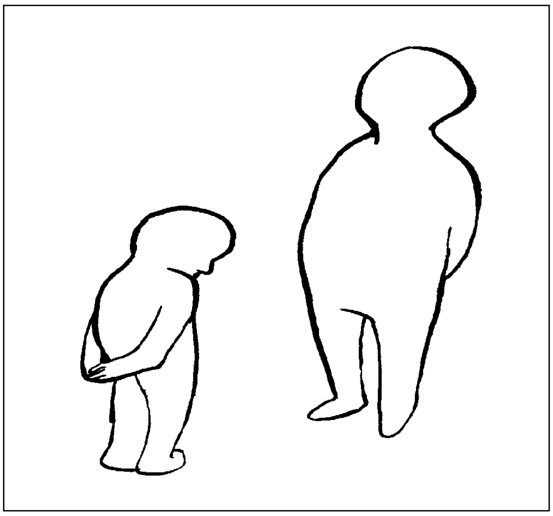

Was ist für die Person in dieser Situation wichtig und was tut sie?

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Warum fühlt sich die Person so?

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Wie geht die Geschichte aus?

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MET/MUT

MUT-K30

Fragebogen-Nr.:_________________ Datum:_________________

Alter:_______________ Geschlecht: ( )w ( )m

Schulabschluß/Studiengang:_______________________

Ausbildung/Beruf:_________________________

Bitte machen Sie die Angaben spontan, ohne lange nachzudenken.

		trifft **gar nicht** zu	trifft **etwas** zu	trifft **über-wiegend** zu	trifft **ausge-sprochen** zu
1.	Wie ich mich einem Menschen gegenüber verhalte, ist irgendwie von all dem bestimmt, was ich mit ihm schon erlebt habe.	( )	( )	( )	( )
2.	Ich mag körperliche Nähe zu anderen Menschen.	( )	( )	( )	( )
3.	Ich mache mir oft Gedanken darüber, was mein Verhalten bei Freunden oder Partner/In bewirkt.	( )	( )	( )	( )
4.	Wenn ich auf Ablehnung stoße, bin ich wie gelähmt.	( )	( )	( )	( )
5.	Wenn ich meine Meinung äußere, fühle ich mich meist ganz frei, das zu sagen, was ich wirklich vertreten kann.	( )	( )	( )	( )
6.	Wie ich meinen Stil zeigen kann, spüre ich immer ganz intuitiv.	( )	( )	( )	( )
7.	Wenn ich eine einflußreiche Position erreicht habe, drängt es mich immer weiter nach oben.	( )	( )	( )	( )
8.	Wenn andere nicht von selbst merken, was ich brauche, verzichte ich lieber darauf.	( )	( )	( )	( )
9.	Wenn ich an meine bisherigen Leistungen denke, fühle ich mich ganz wohl.	( )	( )	( )	( )
10.	Neue Aufgaben gehe ich ganz aus dem Gefühl an.	( )	( )	( )	( )

	trifft **gar nicht** zu	trifft **etwas** zu	trifft **über-wiegend** zu	trifft **ausge-sprochen** zu
11. Je schwieriger eine Aufgabe wird, desto zäher wird mein Durchhaltevermögen.	( )	( )	( )	( )
12. Auch bei noch so guten Leistungen sehe ich immer die kritischen Punkte.	( )	( )	( )	( )
13. Es macht mir Freude, mich mit anderen Menschen auszutauschen.	( )	( )	( )	( )
14. Oft suche ich regelrecht die Auseinandersetzung mit anderen.	( )	( )	( )	( )
15. Wenn ich eine schwierige Aufgabe gelöst habe, suche ich mir am liebsten gleich die nächste Herausforderung.	( )	( )	( )	( )
16. Wenn eine Beziehung belastet wird, wachsen mir ganz neue Kräfte zu.	( )	( )	( )	( )
17. Oft spüre ich das intensive Bedürfnis anderen nah zu sein.	( )	( )	( )	( )
18. Wenn ich eine Partnerschaft oder Freundschaft habe, überlege ich oft, was man noch besser machen kann.	( )	( )	( )	( )
19. Wenn mich jemand nicht mag, geht mir das lange nach.	( )	( )	( )	( )
20. Wenn mir jemand über den Mund fährt, habe ich gleich die passende Reaktion parat.	( )	( )	( )	( )
21. Ich fühle mich anderen oft überlegen.	( )	( )	( )	( )
22. Wenn ich jemanden von etwas überzeugen will, überlege ich mir gut, auf was er am ehesten anspricht.	( )	( )	( )	( )
23. Wenn jemand sehr selbstbewußt auftritt, halte ich mich eher zurück.	( )	( )	( )	( )
24. Bei den Aufgaben, die ich im Alltag bearbeite, fühle ich mich ziemlich frei, so vorzugehen, wie ich es für richtig halte.	( )	( )	( )	( )
25. Ich muß neue Aufgaben mögen, sonst läuft nichts.	( )	( )	( )	( )
26. Im Leistungsbereich wähle ich mir am liebsten die schwierigsten Aufgaben aus.	( )	( )	( )	( )
27. Fehlschläge nehmen mir meist völlig den Mut.	( )	( )	( )	( )
28. Ich fühle mich in meinem Element, wenn ich mit anderen Menschen plaudern kann.	( )	( )	( )	( )
29. Andere haben es oft gern, wenn ich sage, wo es langgeht.	( )	( )	( )	( )

	trifft **gar nicht** zu	trifft **etwas** zu	trifft **über-wiegend** zu	trifft **ausge-sprochen** zu
30. Wenn es eine schwierige Aufgabe anzupacken gilt, melde ich mich oft freiwillig.	( )	( )	( )	( )
31. Wenn ich in eine Gruppe komme, entwickle ich schnell ein gutes Gespür dafür, welche Themen jede einzelne Person ansprechen und welche nicht.	( )	( )	( )	( )
32. Menschen in meiner Nähe nehmen meist meine ganze Aufmerksamkeit ein.	( )	( )	( )	( )
33. In einer Freundschaft überlege ich mir oft, welche Folgen mein Verhalten für die Beziehung hat.	( )	( )	( )	( )
34. Wenn jemand unfreundlich zu mir ist, macht mich das ganz fertig.	( )	( )	( )	( )
35. Wenn ich mit meiner Auffassung nicht durchkomme, drehe ich erst richtig auf.	( )	( )	( )	( )
36. Stil ist mir sehr wichtig im Leben.	( )	( )	( )	( )
37. Wenn es um Macht geht, ist für mich nur die erste Position gut genug.	( )	( )	( )	( )
38. Auch wenn ich mit einem Menschen ganz gut auskomme, sehe ich meistens Punkte, in denen ich unterlegen bin.	( )	( )	( )	( )
39. Mit meinen bisherigen Leistungen im Leben bin ich recht zufrieden.	( )	( )	( )	( )
40. Ich kann gute Leistungen nur erbringen, wenn ich spontan Lust dazu habe.	( )	( )	( )	( )
41. Am meisten reizen mich die ganz schwierigen Aufgaben.	( )	( )	( )	( )
42. Auch wenn mir etwas gelungen ist, sehe ich immer noch irgend etwas, das noch nicht ganz in Ordnung ist.	( )	( )	( )	( )
43. Menschliche Nähe ist mir in meinem Leben wichtiger als Leistung.	( )	( )	( )	( )
44. In meinen Tagträumen spiele ich oft die Heldenrolle.	( )	( )	( )	( )
45. Wenn ich stundenlang an einer schwierigen Sache arbeiten kann, bin ich rundum glücklich.	( )	( )	( )	( )
46. Ich finde immer wieder Menschen, mit denen ich echte Gefühle austauschen kann.	( )	( )	( )	( )
47. Im Umgang mit anderen lasse ich mich ganz von meinen Gefühlen leiten.	( )	( )	( )	( )
48. Von einer Partnerschaft erwarte ich viel.	( )	( )	( )	( )

	trifft **gar nicht** zu	trifft **etwas** zu	trifft **über-wiegend** zu	trifft **ausge-sprochen** zu
49. Wenn ich jemanden kennenlerne, habe ich oft Angst, abgelehnt zu werden.	( )	( )	( )	( )
50. Ich bin sehr schlagfertig.	( )	( )	( )	( )
51. Gefühle der Überlegenheit tun mir gut.	( )	( )	( )	( )
52. Ich strebe zu immer höheren Führungs-positionen.	( )	( )	( )	( )
53. Es fällt mir oft schwer, einzuschätzen, ob ich gegen einen anderen Menschen ankomme oder nicht.	( )	( )	( )	( )
54. Mit den meisten Aufgaben, die ich übernehme, kann ich mich voll und ganz identifizieren.	( )	( )	( )	( )
55. Wenn man Leistung von mir erwartet, verliere ich die Lust.	( )	( )	( )	( )
56. Mein Leistungswille ist unersättlich.	( )	( )	( )	( )
57. Ein Mißerfolg kann mir total den Schwung nehmen.	( )	( )	( )	( )
58. Ich mag es, mit netten Menschen über alles mögliche zu reden.	( )	( )	( )	( )
59. Wenn ich weiß, was ich will, möchte ich auch andere dafür begeistern.	( )	( )	( )	( )
60. Oft suche ich mir ganz spontan eine Beschäftigung, bei der ich meine Fähigkeiten prüfen kann.	( )	( )	( )	( )
61. Früher habe ich mir häufig gewünscht, leichter mit anderen ins Gespräch zu kommen.	( )	( )	( )	( )
62. Ich wünschte, mehr Menschen zu kennen, zu denen Nähe und ein herzlicher Austausch möglich ist.	( )	( )	( )	( )
63. Meine Schulzeit war durch viele Mißerfolge und unangenehme Erlebnisse gekennzeichnet.	( )	( )	( )	( )
64. Ich bin mit meinem beruflichen Erfolg zufrieden.	( )	( )	( )	( )
65. Es macht mir Angst, Stärke zu zeigen.	( )	( )	( )	( )
66. In einer Gruppe eine Aufgabe zu übernehmen kann mir Angst machen.	( )	( )	( )	( )
67. Wenn andere sich hervortun, fällt es mir schwer, mich selbst gebührend einzubringen.	( )	( )	( )	( )
68. Wenn andere ihren Status betonen, fühle ich mich oft unterbewertet.	( )	( )	( )	( )

	trifft **gar nicht** zu	trifft **etwas** zu	trifft **über-wiegend** zu	trifft **ausge-sprochen** zu
69. Verächtliches Gehabe anderer kann mich sehr verletzen.	( )	( )	( )	( )
70. In meiner Kindheit haben mir oft andere Personen ihren Willen aufgezwungen.	( )	( )	( )	( )
71. Es fällt mir schwer, andere zu kritisieren.	( )	( )	( )	( )
72. In meiner Jugend hätte ich mir mehr Kontakte gewünscht.	( )	( )	( )	( )
73. Ich wünschte mir mehr Leute, mit denen man lustige oder interessante Sachen unternehmen könnte.	( )	( )	( )	( )
74. Bei den Klassenarbeiten war ich mit dem Ergebnis oft sehr unzufrieden.	( )	( )	( )	( )
75. Ich bin unzufrieden mit dem, was ich erreicht habe.	( )	( )	( )	( )
76. Es fällt mir schwer, mich anderen gegenüber ins rechte Licht zu rücken.	( )	( )	( )	( )
77. Auch wenn man mich darum bitten würde, hätte ich Hemmungen, eine Gruppe zu leiten.	( )	( )	( )	( )
78. Starkes Auftreten anderer macht mir Angst.	( )	( )	( )	( )
79. Ich mache mich anderen gegenüber oft kleiner als ich bin.	( )	( )	( )	( )
80. Ich fühle mich von anderen oft nicht ernst genug genommen.	( )	( )	( )	( )
81. Als Kind war ich oft frustriert, weil ich nicht meinen Willen zeigen durfte.	( )	( )	( )	( )
82. Bei Auseinandersetzungen gebe ich meist nach.	( )	( )	( )	( )
83. Als Kind hätte ich gerne mehr Geselligkeit gehabt.	( )	( )	( )	( )
84. Ich hätte gerne engere Beziehungen zu Menschen, die mir wichtig sind.	( )	( )	( )	( )
85. Als Kind waren meine Leistungen oft schlechter als ich es mir gewünscht hätte.	( )	( )	( )	( )
86. Meine Leistungen werden zu wenig anerkannt.	( )	( )	( )	( )
87. Es wäre mir unangenehm, in einer Gruppe das Sagen zu haben.	( )	( )	( )	( )
88. Die Verantwortung für das Geschick anderer zu übernehmen würde mir Angst machen.	( )	( )	( )	( )
89. Ich kann es nicht gut haben, wenn andere ihre starken Seiten ungeniert zeigen.	( )	( )	( )	( )

	trifft **gar nicht** zu	trifft **etwas** zu	trifft **über-wiegend** zu	trifft **ausge-sprochen** zu
90. Wenn andere selbstbewußt auftreten, schrumpft mein Selbstbewußtsein.	( )	( )	( )	( )
91. Ich spüre abfällige Bemerkungen mir gegenüber, auch wenn jemand sie nur indirekt andeutet.	( )	( )	( )	( )
92. Ich habe mich in meiner Kindheit und Jugend gegenüber dem Einfluß anderer oft sehr frustriert gefühlt.	( )	( )	( )	( )
93. Ich wünschte mir weniger Menschen, die mich bevormunden wollen.	( )	( )	( )	( )
94. Als Kind hatte ich weniger Freunde als ich gern gehabt hätte.	( )	( )	( )	( )
95. Ich wäre zufriedener, wenn ich öfter mit Freunden, Bekannten oder Kollegen ausgehen könnte.	( )	( )	( )	( )
96. Meine Eltern waren mit meinen Leistungen zufrieden.	( )	( )	( )	( )
97. Manchmal leide ich darunter, daß ich meine Begabungen nicht ausreichend verwirklichen kann.	( )	( )	( )	( )
98. Andere von meiner Meinung zu überzeugen, liegt mir nicht.	( )	( )	( )	( )
99. Verantwortung zu übernehmen macht mir Angst.	( )	( )	( )	( )
100. Ich kann es schlecht haben, wenn andere den Ton angeben.	( )	( )	( )	( )
101. Ich ärgere mich zuweilen darüber, daß ich mich durch oberflächliches Gehabe anderer einschüchtern lasse.	( )	( )	( )	( )
102. Mir tut es weh, wenn andere keinen Respekt vor mir haben.	( )	( )	( )	( )
103. Als Kind bin ich zu oft von anderen kommandiert worden.	( )	( )	( )	( )
104. Ich wünschte, es gäbe nicht so viele Menschen, die anderen ihre Ansichten aufdrängen.	( )	( )	( )	( )
105. Ich setze mich gern für andere Menschen ein.	( )	( )	( )	( )
106. Ich habe Freude daran, für die Anliegen anderer zu kämpfen.	( )	( )	( )	( )

	trifft **gar nicht** zu	trifft **etwas** zu	trifft **über-wiegend** zu	trifft **ausge-sprochen** zu
107. Ich habe die Fähigkeit, andere für eine gute Sache zu gewinnen.	( )	( )	( )	( )
108. In einer Gruppe sorge ich meist für den Zusammenhalt.	( )	( )	( )	( )
109. Ich mag Geselligkeit.	( )	( )	( )	( )
110. Ich mag unkomplizierte Menschen am liebsten.	( )	( )	( )	( )
111. Ich mag nette Konversation lieber als tiefgründige Gespräche.	( )	( )	( )	( )
112. Ich komme mit den meisten Leuten ganz gut zurecht.	( )	( )	( )	( )
113. Ich fühle mich am wohlsten bei Menschen, die ich gut kenne.	( )	( )	( )	( )
114. In einer Liebesbeziehung ist mir Geborgenheit sehr wichtig.	( )	( )	( )	( )
115. Ich schätze Freunde, auf die man sich in jeder Lebenslage verlassen kann.	( )	( )	( )	( )
116. Ich brauche einen Menschen, der mich versteht.	( )	( )	( )	( )
117. Eine Leistung ist für mich ein Erfolg, wenn ich im Vergleich zu anderen gut abschneide.	( )	( )	( )	( )
118. Ich vergleiche meine Leistungen oft mit denen anderer.	( )	( )	( )	( )
119. Besser sein zu wollen als andere, ist für mich ein starker Ansporn.	( )	( )	( )	( )
120. Ob eine Leistung gut ist, hängt für mich vom Urteil anderer ab.	( )	( )	( )	( )
121. Im Wetteifer mit anderen entwickle ich meinen Leistungswillen am besten.	( )	( )	( )	( )
122. Leistung heißt besser sein als andere.	( )	( )	( )	( )

NEO FFI

Diese Seite kann aus lizenztechnischen Gründen nicht angezeigt werden.

PANAS

Diese Seite kann aus lizenztechnischen Gründen nicht angezeigt werden.

ARES – BIS / BAS

ACS / HAKEMP

Bitte markieren Sie zu jeder Frage immer diejenige der beiden Antwortmöglichkeiten (*a* oder *b*) auf dem Antwortbogen, die für Sie eher zutrifft.

(1) **Wenn ich etwas Wertvolles verloren habe und jede Suche vergeblich war, dann**

a) kann ich mich schlecht auf etwas anderes konzentrieren. O
b) denke ich nicht mehr lange darüber nach. O

(2) **Wenn ich weiß, daß etwas bald erledigt werden muß, dann**

a) muß ich mir oft einen Ruck geben, um den Anfang zu kriegen. O
b) fällt es mir leicht, es schnell hinter mich zu bringen. O

(3) **Wenn ich vier Wochen lang an einer Sache gearbeitet habe und dann doch alles mißlungen ist, dann**

a) dauert es lange, bis ich mich damit abfinde. O
b) denke ich nicht mehr lange darüber nach. O

(4) **Wenn ich nichts Besonderes vorhabe und Langeweile habe, dann**

a) kann ich mich manchmal nicht entscheiden, was ich tun soll. O
b) habe ich meist rasch eine neue Beschäftigung. O

(5) **Wenn ich bei einem Wettkampf öfter hintereinander verloren habe, dann**

a) denke ich bald nicht mehr daran. O
b) geht mir das noch eine ganze Weile durch den Kopf. O

(6) **Wenn ich ein schwieriges Problem angehen will, dann**

a) kommt mir die Sache vorher wie ein Berg vor. O
b) überlege ich, wie ich die Sache auf eine einigermaßen angenehme Weise hinter mich bringen kann. O

(7) **Wenn mir ein neues Gerät versehentlich auf den Boden gefallen und nicht mehr zu reparieren ist, dann**

a) finde ich mich rasch mit der Sache ab. O
b) komme ich nicht so schnell darüber hinweg. O

(8) **Wenn ich ein schwieriges Problem lösen muß, dann**

a) lege ich meist sofort los. O
b) gehen mir zuerst andere Dinge durch den Kopf, bevor ich mich richtig an die Aufgabe heranmache. O

(9) **Wenn ich jemanden, mit dem ich etwas Wichtiges besprechen muß, wiederholt nicht zu Hause antreffe, dann**

a) geht mir das oft durch den Kopf, auch wenn ich mich schon mit etwas anderem beschäftige. O
b) blende ich das aus, bis die nächste Gelegenheit kommt, ihn zu treffen. O

(10) **Wenn ich vor der Frage stehe, was ich in einigen freien Stunden tun soll, dann**

a) überlege ich manchmal eine Weile, bis ich mich entscheiden kann. O
b) entscheide ich mich meist ohne Schwierigkeit für eine der möglichen Beschäftigungen. O

(11) **Wenn ich nach einem Einkauf zu Hause merke, daß ich zu viel bezahlt habe, aber das Geld nicht mehr zurückbekomme,**

a) fällt es mir schwer, mich auf irgendetwas anderes zu konzentrieren. O
b) fällt es mir leicht, die Sache auszublenden. O

(12) **Wenn ich eigentlich zu Hause arbeiten müßte, dann**

a) fällt es mir oft schwer, mich an die Arbeit zu machen. O
b) fange ich meist ohne weiteres an. O

(13) **Wenn meine Arbeit als völlig unzureichend bezeichnet wird, dann**

a) lasse ich mich davon nicht lange beirren. O
b) bin ich zuerst wie gelähmt. O

(14) **Wenn ich sehr viele wichtige Dinge zu erledigen habe, dann**

a) überlege ich oft, wo ich anfangen soll. O
b) fällt es mir leicht, einen Plan zu machen und ihn auszuführen. O

(15) **Wenn ich mich verfahre (z. B. mit dem Auto, mit dem Bus usw.) und eine wichtige Verabredung verpasse, dann**

a) kann ich mich zuerst schlecht aufraffen, irgendetwas anderes anzupacken. O
b) lasse ich die Sache erst mal auf sich beruhen und wende mich ohne Schwierigkeiten anderen Dingen zu. O

(16) **Wenn ich zu zwei Dingen große Lust habe, die ich aber nicht beide machen kann, dann**

a) beginne ich schnell mit einer Sache und denke gar nicht mehr an die andere. O
b) fällt es mir nicht so leicht, von einer der beiden Sachen ganz Abstand zu nehmen. O

(17) **Wenn mir etwas ganz Wichtiges immer wieder nicht gelingen will, dann**

a) verliere ich allmählich den Mut. O
b) vergesse ich es zunächst einmal und beschäftige mich mit anderen Dingen. O

(18) **Wenn ich etwas Wichtiges, aber Unangenehmes zu erledigen habe, dann**

a) lege ich meist sofort los. O
b) kann es eine Weile dauern, bis ich mich dazu aufraffe. O

(19) **Wenn mich etwas traurig macht, dann**

a) fällt es mir schwer, irgendetwas anderes zu tun. O
b) fällt es mir leicht, mich durch andere Dinge abzulenken. O

(20) **Wenn ich vorhabe, eine umfassende Arbeit zu erledigen, dann**

a) denke ich manchmal zu lange nach, womit ich anfangen soll. O
b) habe ich keine Probleme loszulegen. O

(21) **Wenn einmal sehr viele Dinge am selben Tag misslingen, dann**

a) weiß ich manchmal nichts mit mir anzufangen. O
b) bleibe ich fast genauso tatkräftig, als wäre nichts passiert. O

(22) **Wenn ich vor einer langweiligen Aufgabe stehe, dann**

a) habe ich meist keine Probleme, mich an die Arbeit zu machen. O
b) bin ich manchmal wie gelähmt. O

(23) **Wenn ich meinen ganzen Ehrgeiz darin gesetzt habe, eine bestimmte Arbeit gut zu verrichten und es geht schief, dann**

a) kann ich die Sache auf sich beruhen lassen und mich anderen Dingen zuwenden. O
b) fällt es mir schwer, überhaupt noch etwas zu tun. O

(24) **Wenn ich unbedingt einer lästigen Pflicht nachgehen muss, dann**

a) bringe ich die Sachen ohne Schwierigkeiten hinter mich. O
b) fällt es mir schwer, damit anzufangen. O

Appendix B: Curriculum Vitae

ZUR PERSON

Geburtsdatum	12.11.1978
Geburtsort	Georgsmarienhütte
Staatsangehörigkeit	deutsch
Familienstand	verheiratet, ein Kind

AKADEMISCHE UND BERUFLICHE AUSBILDUNG

Seit 04/2012

Universität Osnabrück, Osnabrück
Weiterbildung zum psychologischen Psychotherapeuten
Schwerpunkt: Verhaltenstherapie
Voraussichtliche Approbation: 04/2017

Seit 11/2008

Universität Osnabrück, Osnabrück
Promotion am Institut für Kognitionswissenschaften / Differentielle und Persönlichkeitspsychologie (Prof. Dr. J. Kuhl)
Thema: Cerebral Asymmetries, Motivation, and Cognitive Processing: An Analysis of Individual Differences

10/2001 – 10/2008

Universität Osnabrück, Osnabrück
Studium der Psychologie auf Diplom
Schwerpunktfach: Klinische Psychologie
Nebenfach: Psychosomatik
Vertiefungsfach: Psychopathologie
Abschluss: Sehr Gut (1,2)

08/1999 – 06/2001

Firma Westland Gummiwerke GmbH, Westerhausen
Ausbildung zum Industriekaufmann
Abschluss: Industriekaufmann (IHK)

BERUFLICHE TÄTIGKEITEN

Seit 05/2013

Universität Osnabrück, Osnabrück
Wissenschaftlicher Mitarbeiter im Fachgebiet Allgemeine Psychologie 1 (Prof. Dr. T. Gruber)
Schwerpunkte: EEG-Forschung und Kausalitätsanalysen, Durchführung von Lehrveranstaltungen, Betreuung von Studierenden und Abschlussarbeiten

Seit 04/2013

REHA-Zentrum am Hesselkamp (RPK), Osnabrück
Psychologe in Ausbildung
Psychotherapeutische Gespräche, Krisenintervention

Behandlung verschiedener psychischer Erkrankungen: Schizophrenie, Depression, Soziale Phobie, Suchterkrankungen, Persönlichkeitsstörungen, körperdysmorphe Störungen

Diagnostik mit folgenden Instrumenten: AVLT, SPM, WST, PSSI, IIP, SCL-90R, ZVT, WIE, BDI-2, d2

05/2012 - 05/2013 **Dr. Becker Neurozentrum Niedersachsen, Bad Essen**

Klinischer Psychologe in der Neuropsychologie

Schwerpunkte: Diagnostik und Therapie neurologischer Patienten z.B. nach Schlaganfällen, Schädel-Hirn-Traumata, Multipler Sklerose

Beratungsgespräche zur Krankheitsbewältigung mit Patienten und Angehörigen

Diagnostik mit folgenden Instrumenten: LPS, WIE, TAP 2.1, SCL, BDI-2, d2, VLMT, Turm von London, TMT A&B

Mitarbeit im multidisziplinären Team (Psychologen, Logopäden, Physiotherapeuten, Internisten, Neurologen), z.B. Dienstbesprechungen zu Fällen und deren Therapiebedarfsermittlung

11/2008 - 05/2012 **Universität Osnabrück, Osnabrück**

Stipendium am Institut für Kognitionswissenschaften im interdisziplinären Graduiertenkolleg:

„Adaptivity in Hybrid Cognitive Systems"

06/2001 – 09/2001 **Firma Westland Gummiwerke GmbH, Westerhausen**

Anstellung als Mitarbeiter

SONSTIGE TÄTIGKEITEN

01/2009 – 12/2010 **Summative Evaluation für die Kinderrechtsorganisation *terre des hommes* e.V.**

Evaluation des Programms „Kinder haben Rechte - überall!" in Zusammenarbeit mit Dr. Manuel Waldorf, Dipl.-Psych.

WEHRERSATZDIENST

07/1998 – 08/1999 **Paritätischer Wohlfahrtsverband, Osnabrück**

Individuelle Schwerstbehindertenbetreuung

SCHULISCHE AUSBILDUNG

08/1991 – 06/1998 **Ratsgymnasium, Osnabrück**

Abschluss: Allgemeine Hochschulreife

Appendix C: Declaration (Erklärung)

Erklärung über die Eigenständigkeit der erbrachten wissenschaftlichen Leistung

Ich erkläre hiermit, dass ich die vorliegende Arbeit ohne unzulässige Hilfe Dritter und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe. Die aus anderen Quellen direkt oder indirekt übernommenen Daten und Konzepte sind unter Angabe der Quelle gekennzeichnet.

Bei der Auswahl und Auswertung folgenden Materials haben mir die nachstehend aufgeführten Personen in der jeweils beschriebenen Weise entgeltlich/ unentgeltlich geholfen.

Weitere Personen waren an der inhaltlichen materiellen Erstellung der vorliegenden Arbeit nicht beteiligt. Insbesondere habe ich hierfür nicht die entgeltliche Hilfe von Vermittlungs- bzw. Beratungsdiensten (Promotionsberater oder andere Personen) in Anspruch genommen. Niemand hat von mir unmittelbar oder mittelbar geldwerte Leistungen für Arbeiten erhalten, die im Zusammenhang mit dem Inhalt der vorgelegten Dissertation stehen.

Die Arbeit wurde bisher weder im In- noch im Ausland in gleicher oder ähnlicher Form einer anderen Prüfungsbehörde vorgelegt.

....
(Ort. Datum) (Unterschrift)