Creativity:
Theories, Prediction, and Etiology

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1. Introduction

1.1 Background

Creativity is a phenomenon that has always fascinated lay people as well as scientists. It is for example valued as a property of pieces of art or literature, musical compositions, scientific works, narrations, witty comments, decorations, and technical or social inventions. In all these various facets, creativity is a prime source of cultural progress and responsible for a multitude of small contributions to our everyday enjoyment and well-being. Because of these effects, it is also appreciated as an attribute of employees, artists, entertainers, scientists, friends and mates. Its social and cultural importance led just about every major personality psychologist of the 20th century – be it Freud, Jung, Adler, Skinner, Maslow, Murray, Rogers, Kelly, Guilford, Cattell, or Eysenck – to write about creativity (Woodman, 1981).

Mayer (1999) reviewed seven definitions given by authors contributing to the 1999 ‘Handbook of Creativity’ (Sternberg, 1999), and summarized them as “[…] creativity involves the creation of an *original* and *useful* product.” (italics in original). This definition can account as representative for those traditionally used in psychology (see also Stein, 1953; MacKinnon, 1962). Under different perspectives, creativity can be studied as a property of a person, process, product or even situation. In the light of the important, yet often ignored, hedonistic function of creativity, I want to emphasize the necessity of a subjective aspect in this definition. Its second part, ‘useful’, should explicitly include the potential of a creative product to satisfy subjective aesthetic needs. Without doubt, there are areas of creative endeavor where more objective criteria can and should be used. In evaluating the creativity of a scientific theory, for example, criteria like parsimony or practical and explanatory value should be given precedence. But most products valued for creativity – especially in the arts and in everyday life - do not belong to such areas. Generally excluding the aesthetic aspect for the mere sake of simplicity, as suggested by Runco (1993), would make it hard to find a reason why things like paintings, poems, songs or jokes should be valued by people at all. Indeed, attempts to validate a more objective definition of usefulness (or appropriateness) as an aspect of creativity have failed (Runco & Charles, 1993). Contrary to common prejudices, subjective evaluations of aesthetic appeal are by no means purely idiosyncratic or arbitrary. After all, aesthetic preferences stem from cognitive and emotional adaptations which are evolved solutions

to recurring problems in our phylogenetic history (Voland & Grammer, 2003). Thornhill (2003) put it this way: “I am arguing that intellectual aesthetic value represents a functionally based way of dealing with a cultural environment that is full of diverse ideas. In this perspective, cultural learning of values is not arbitrary. Learning mechanisms, in conjunction with feeling mechanisms and mechanisms of self-awareness that allow us to test how our ideas and behaviors are perceived by others, guide us through a maze of ideas towards intellectual beauty. Appropriate values will often differ between societies and within societies between social strata and individuals.” Not surprisingly, Amabile (1982, 1983a) found across several studies that people do show considerable interjudge agreement (around .80) on the creativity of products, even when they use their own definition of what is creative. She suggested a consensual definition of creativity, stating that “[a] product or response is creative to the extent that appropriate observers independently agree it is creative. Appropriate observers are those familiar with the domain in which the product was created or the response articulated” (Amabile, 1982, p. 1001). The present thesis will use Amabile’s definition as a necessary supplement to the traditional one.

Over 50 years after Guilford’s (1950) APA presidential address ignited the intensive scientific study of creativity, it is still much less understood than other psychological constructs (Brown, 1989). Many questions, some of them fundamental ones, must be regarded unanswered (Mayer, 1999). Several of these questions concern the person perspective on creativity (Simonton, 1999a). Despite the opinion of some early sociologists and anthropologists, who attributed the advent of creative products solely to environmental factors (e.g. Sorokin, 1937-1941; White, 1949), a position that has been proven as too parsimonious (Simonton, 1988, 1999a), the mere existence of individual differences in a disposition towards creativity (Barron, 1955) is now widely accepted. Its very nature, however, the answer to the central question “What makes a person creative?”, remains unclear. Especially urgent issues include (1) how creativity relates to cognitive variables such as general intelligence, (2) which personality traits facilitate or are necessary for a creative thinking style, (3) the etiology of creativity, and (4) the heterogeneity of creativity. All of these issues will be dealt with in this thesis.

1.2 Cognitive influences on creativity

The relationship of individual differences in creativity to individual differences in cognitive abilities, such as intelligence, is still discussed. Indeed, any possible relationship between creativity and intelligence has been proposed (Sternberg & O'Hara, 1999). In one extreme version, creativity and intelligence are regarded as totally independent, a position especially taken by some cognitive psychologists with strong focus on the creative process (Hayes, 1989; Weisberg, 1992, 1999; Klahr & Simon, 1992). These authors see creativity as a mental operation accessible to everyone, only dependent on domain-specific knowledge (i.e. the amount of exposure to and expertise in a given field) and deliberate practice. Their position therefore denies not only the influence of intelligence, but of any individual difference beyond knowledge and motivational factors, on creativity. While the results from research on problem solving and insight are exhaustive and surely noteworthy, such a strong position might be too neglectful and mainly reflective of the unfortunate, but still existing intellectual borders between psychological subdisciplines in general (Gigerenzer, 1998) and particularly experimental and correlational approaches (Cronbach, 1957): As pointed out by Simonton (2003), it is difficult to conceive a basic creative process which is neither enhanced nor inhibited by at least one individual-difference variable that has been empirically associated with actual creative behavior. One of these variables surely is psychometric intelligence.

But contrary to some early believes of the other extreme, a high IQ ('giftedness'; Jensen, 1996) has proven as insufficient for creativity ever since Terman's (1925; Burks, Jensen & Terman, 1930; Terman & Oden, 1947, 1959) famous longitudinal study of 1528 highly gifted children, which had a mean IQ of 151. While most of these children achieved remarkable occupational success in later life, none of them showed a noteworthy sign of creativity (see Eysenck (1995a) for an extensive review of the Terman study). Indeed, most of the numerous empirical studies concerning the association between psychometric intelligence and creativity yielded only a weak relationship (Barron & Harrington, 1981). For example, Torrance (1975) reported that the median of 178 correlation coefficients between IQ and the Torrance Test of Creative Thinking (TTCT; Torrance, 1974) was only .20, and Hocevar (1980) reported a correlation of .26 between IQ and mean self-reported creative activities and accomplishments across various domains in a sample of 94 students. Not surprisingly, common factor analyses of IQ and creativity tests yielded separate factors (see

Amelang & Bartussek, 1997, p. 274). When Carroll (1993) re-analyzed 42 data sets that included creativity tests for his Three Striatum Taxonomy of Intelligence, he found a factor loaded highly by these test that “represents a distinct dimension of individual differences that is linearly independent of other such dimension” (p. 427) and “can be measured with considerable reliability” (p. 431). Consequently, not even the strongest proponents of a g factor of general intelligence, from Spearman and the early British School (Hargreaves, 1927) to Eysenck (1995a) and Jensen (1996), doubt the differences between intelligence and creativity.

Yet a creative person’s IQ is practically inevitably at least a standard deviation above the mean, often more (Cox, 1926; Haensly & Reynolds, 1989; Simonton, 1984, 1999a). These apparently contradicting findings were integrated by Guilford (1967a, p. 168, 1967b, 1981) to a threshold hypothesis of creativity. The hypothesis stated that a minimal level of IQ, often rather arbitrary set to 120, should be necessary, but not sufficient for creativity. Recognized creative achievement was thought to be impossible below this threshold (Simonton, 1994). Guilford proposed that the correlation between IQ and creativity should be insignificant above an IQ of 120 - a rather week claim because of the inevitable range restriction effect and the fact that all cognitive activities show weaker correlations in high-IQ samples (Detterman & Daniel, 1989). Second, he proposed that scatter plots of IQ and creativity should show a triangular pattern (which gave Guilford’s claim sometimes the name ‘triangularity hypothesis’), with no data points in the low-IQ / high-creativity quadrant. This threshold view of creativity is so plausible that it is widely accepted, though empirical test are scarce and more likely to show a disconfirming tendency (Mednick & Andrews, 1967; Runco & Albert, 1986; Lubinski et al., 2001). A theoretical extension of Guilford’s hypothesis, suggested by Peterson and colleagues (2002; Carson et al., 2003), will be discussed in section 1.4. From a knowledge-centered cognitive perspective, Hayes (1989) proposed an alternative ‘certification hypothesis’, which doubted intrinsic links between creativity and intelligence. Instead, it stated that most possibilities to display a recognizable level of creativity, like occupations in architecture or science, simply require a high level of formal education. Since academic performance is correlated with IQ, society simply denies creative individuals of low IQ the chance to express their talent adequately. It must be noted that exactly the same idea was already discussed by Guilford (1967a, pp. 168-169), who puzzles over cases of triangular IQ-creativity-relationships in children, for whom the ‘certification hypothesis’ would not hold.

Related to these issues is the question if creativity is stronger associated with fluid (g_f) or crystallized intelligence (g_c or a_g; Cattell, 1963, 1971) While the former is more representative of reasoning ability and mental speed, the latter one is more influenced by knowledge and learned response habits to complex cues and is often allocated in tests of verbal ability. Cattell (1971) himself saw creativity, especially real-life creative performance, as mainly determined by fluid intelligence, with the contribution of g_c being small compared it and to personality traits facilitating concentration and impulse restriction in favor of inner activity (p. 443). He argued that "by its very definition and nature, a_g deals with things that are already known, and judgmental skills that have already been applied before" (p. 435), leaving it in the mere role of "a requisite foundation and contribution to the creative steps taken by virtue of g_f" (p. 443) According to him, it also bears the risk of hindering g_f's creative insight through negative transfer (i.e. false application of existing knowledge in a new situation; p. 441). He suggested any relation between creativity and g_c being attributable to its substantial empirical confoundation with g_f. This view is challenged by studies of Crawford (1974; Crawford & Nirmal, 1976), who found stronger relations of test creativity (measured by the TTCT) to g_c than to g_f in multivariate analyses of data from 172 and 163 elementary school children. Differences between g_f and g_c were, however, small, and divergent test such as the TTCT are questionable creativity criteria (see below).

Beside intelligence, a second and rather independent cognitive component of creativity is widely acknowledged (e.g. Guilford, 1967a, b; Amabile, 1983a, b; Sternberg & Lubart, 1995; Eysenck, 1993, 1995a; Jensen, 1996; Simonton, 1999a, b): A cognitive style of divergent (Guilford, 1950) or associational thinking (Mednick, 1962), sometimes called originality (Eysenck, 1993). Guilford's approach to this cognitive style got much attention after he included it as an own operation dimension ('divergent production') in his famous Structure of Intelligence (SOI) model and operationalised it in form of divergent (production) tests (Guilford, 1967a). These divergent test, of whom beside Guilford's (1967a) those of Torrance (1974) and Wallach & Kogan (1965) are well-known examples, deviate from standard 'convergent' cognitive abilities tests in demanding not one right answer, but as many different responses as possible, like various uses for an object or titles for a short story. The responses are subsequently scored on objective scales measuring assumingly different dimensions of creative ability, traditionally fluency (number of responses), flexibility (number of different categories covered by the

responses), originality (statistical infrequency of the responses) and elaboration (amount of details given).

Tests of divergent production have often been criticized. While they do show a considerable amount of convergent validity (e. g. Barron, 1968) and do often relate to non-test indices of creativity (Barron & Harrington, 1981), their content validity has often been questioned (e. g. Wallach, 1971; Cattell, 1971; Barron & Harrington, 1981; Brown, 1989). After presenting an extensive taxonomy and critique of creativity measures, Hocevar & Bachelor (1989) suggested using divergent tests only as a measure of a subcomponent of creativity, but warn against using them as the only criterion. Additionally, the scoring dimensions of divergent tests have been shown to lack discriminant validity and to depend exclusively on fluency (that is, all other dimensions lack internal consistency and convergent validity when fluency is statistically controlled; Hocevar, 1979a, b). Even though Hocevar proved this detrimental effect for objectively determined originality (i.e. statistical infrequency) as well as for subjectively rated originality, he (Hocevar, 1979a) and also Eysenck (1995a, p. 93) suggested subjective originality ratings by several raters with controlling for number of responses as the scoring method of choice. According to Hocevar (1979a), number of responses can be controlled either by using item means as total scores, by requiring only a certain number of responses per item in the instructions, or by scoring only a certain number of responses per item. Note that this approach is very much in line with Amabile's (1982) consensual definition of creativity (discussed in section 1.1).

In the literature, individual differences in a disposition towards an original cognitive style have been closer linked to temperamental factors and personality traits than to pure cognitive abilities. Therefore, in the next two sections, I will shortly review empirical findings on and theoretical integrations of creativity and personality.

1.3 Creativity and personality

The first-ever meta-analysis in the field of creativity research was conducted by Feist (1998) and dealt with the personality of creative people. More precisely, Feist analyzed the results from 26 studies comparing scientists vs. non-scientists (total N = 4852), 28 studies comparing more creative vs. less creative scientists (total N = 3918) and 29 studies comparing artists vs. non-artists (total N = 4397) according personality traits that

predicted creative achievement (all studies were published ones). As a reference model for all the various traits differentiating between the groups, Feist used the Five-Factor Model of personality (FFM; see John & Srivastava, 1999), which represents the essence of a growing consensus on the taxonomic structure of personality. He classified all traits according to their highest correlation with a FFM factor reported in the literature to either the positive or the negative pole of Neuroticism (N), Extraversion (E), Openness to Experience (O), Agreeableness (A) or Conscientiousness (C), as long as the correlation exceeded .25. The factors of the FFM are constituted as broad dimensions of personality and therefore inevitably blur more fine-grained personality dimensions. Since the relationship between creativity and Extraversion is known to be rather complex (and has even been called paradox (Martindale, 1993; see section 1.4)), Feist used two interrelated subdimensions of Extraversion – confidence/dominance and sociability - additionally to the global dimension of E. Whenever sufficient data was accessible, Feist also used the scales of the California Personality Inventory (CPI; Gough, 1957), the Sixteen Personality Factors Questionnaire (16PF; Cattell, Eber & Tatsuoka, 1970) and the Eysenck Personality Questionnaire (EPQ; Eysenck & Eysenck, 1975) to compare the three pairs of creativity groups. Only the FFM and EPQ results are relevant for the purpose of this thesis, and therefore the CPI and 16PF results will not be discussed. The EPQ measures the three broad superfactors of Eysenck's P-E-N model, Psychoticism (P), Extraversion (E), and Neuroticism (N) (Eysenck & Eysenck, 1985).

The meta-analytic results of the FFM dimensions and somewhat associated traits showed that what differentiated creative from less creative scientists and artists from non-artists is high Openness to Experience (Cohen's d = .31 and .47, respectively; Cohen, 1977), low Conscientiousness (d = .30 and .75), high Extraversion (d =.39 and .15), which is completely attributable to confidence/dominance (d = .40 and .21), but not sociability (d = .00 and .02), and, to a less extend, low Agreeableness (d = .19 and .21). Additionally, artists, but not creative scientists, showed a lower Emotional Stability (N-) compared to their comparison group (d = -.24 and .09, respectively). On the other hand, scientist in general were distinguished from non-scientist by a *higher* Introversion (E-; d = .26) combined with a slightly higher confidence/dominance (d = .17), the latter showing a decline with age, a *lower* Openness to Experience (d = .30) and a much higher Conscientiousness (d = .51) – results that differed markedly from the other two

comparisons. It seems like a scientific occupation imposes much less demand on creativity than an artistic one.

The EPQ results, however, rendered the Extraversion result just reported inconsistent. The congruence of FFM and P-E-N Extraversion has often been poven (see Angleitner & Ostendorf, 2003). It is therefore surprising that EPQ results indicated scientist being more extraverted than non-scientist (d = .33). Feist explained this result solely with the importance to distinguish the confidence/dominance and sociability subdimensions of E. Extraversion showed no noteworthy difference between artists and non-artists, neither did Neuroticism for scientists or artists. Data for comparisons of highly vs. less creative scientists were not available for the EPQ. Scientists and artists, however, markedly differed from the normal population in Psychoticism (d = .45 and .66, respectively).

For all analyses together, Feist concluded: “Creative people are more autonomous, introverted, open to new experiences, norm-doubting, self-confident, self-accepting, driven, ambitious, dominant, hostile, and impulsive. Out of these, the largest effect sizes are on openness, conscientiousness, self-acceptance, hostility, and impulsivity. Yet, creative people in art and science do not completely share the same unique personality profiles: Artists are distinguished more by their emotional instability, coldness, and their rejecting group norms than are scientists. […] Finally, less creative scientists, compared with the effect sizes of their more creative peers in science and in art, are more conscientious, conventional, and closed-minded […].” (pp. 299-300). These conclusions were very much in line with those of an earlier qualitative review by Barron and Harrington (1981, p. 453): “In general, a fairly stable set of core characteristics (e.g., high valuation of esthetic qualities in experience, broad interests, attraction to complexity, high energy, independence of judgment, autonomy, intuition, self-confidence, ability to resolve antinomies or to accommodate apparently opposite of conflicting traits in one’s self-concept, and finally a firm sense of self as “creative”) continued to emerge as correlates of creative achievement and activity in many domains.”

Feist (1998) also reviewed longitudinal studies informative about the temporal order of personality and creativity, and concluded that there is no hint for any influence of creative achievement on subsequent personality: “Every longitudinal study has found that the same traits that distinguish creative people later in life also distinguish them earlier in life. […] Taken in total, longitudinal studies of creative personality over time

suggest that the personality structure of highly creative people tends to remain relatively stable." (Feist, 1998, p. 299; see also Feist & Barron, 2003).

At this point, a cautious remark has to be made. Most reviews of creativity and personality, like those of Feist (1998) or Barron and Harrington (1981), focus on creative achievement. It surely is convincing to see eminence or recognized creative products as the purest criteria of creativity (Hocevar & Bachelor, 1989). But creative achievement in a field, let alone eminence or genius, is without doubt synergistically determined by more than just a disposition towards creativity (e.g. (Amabile, 1983a, b; Woodman & Schoenfeldt, 1989; Eysenck, 1993, 1995a, b; Feist, 1998; Csikszentmihalyi, 1999; Simonton, 1999b; Jensen, 1996; Sternberg & Lubart, 1995). Beside multiple external factors facilitating or inhibiting a creative career (from education, socioeconomic status and home environment to cultural, religious and historical factors to oddities such as season of birth and activity of sunspots; Eysenck, 1995a), some internal factors may be mere catalysts for bringing a creative product to public recognition. The hypothesized function of IQ as a certification for creative occupations has already been discussed (section 1.2). Other possible candidates are self-confidence and dominance, autonomy and independence, ambition and intrinsic motivation, and even a certain degree of hostility and anti-social tendency to defend ones ideas against premature criticism. Some further internal factors may be specific for certain fields, such as emotionality in the arts (Feist, 1998). As long as one conceptualizes the general disposition towards a creative cognitive style as a dimensional trait owned by everyone to a greater or lesser extend, studying everyday creativity in general population samples should lead to less confounded, yet valid estimates (Richards, Kinney, Benet & Merzel, 1988).

Of those studies using less professional subjects, McCrae's (1987) is maybe the most recognized one. In a sample of over 200 adult men, he studied relations between creativity and the Five-Factor Model, intensively measured by different versions of NEO questionnaires (Costa & McCrae, 1992) and an adjective list, all in self-, peer-, and spouse-report form, as well as a Q-Sort. Further personality measures included EPQ Psychoticism. The creativity criteria were five of Guilford's divergent tests, four of which were only scored for fluency, while the fifth (remote consequences) was additionally rated for originality. Since all tests loaded on the same factor, a total sum score was calculated. As a second criterion, Gough's (1979) Creative Personality Scale (CPS), a well-validated, empirically keyed, 30-item adjective scale, was administered. All six measures of Openness to Experience correlated highly significant (between .29 and

.41) with the divergent tests total score, and four remained significant when verbal intelligence, age and years of education (correlated .53, -.19 and .52 with total divergent tests score, respectively) were partialled out. The CPS did also correlate significantly with all Openness measures (between .26 and .61), as well as .26 with the divergent tests total. No other of the FFM factors, neither Psychoticism, showed a consistent relation to the divergent tests. Results of these dimensions were also inconsistent for the CPS, except for Extraversion, which correlated between .16 and .58 with the CPS (five of six coefficients being significant). Note, however, that according to Hocevar and Bachelor (1989), both creativity criteria did not fully qualify as such, since both measured only an aspect of creativity.

While Rawlings and colleagues (1998), also using divergent tests as criteria, were able to replicate McCrae's result of a positive correlation with Openness, the results of Woody and Claridge (1977) contradict those of McCrae in finding a strong association of five Wallach and Kogan (1965) divergent tests with EPQ Psychoticism self-reports (.32 to .45 for fluency, .61 to .68 for originality, both dimensions objectively scored) in 100 British university students. However, replications of Stayte (1977) and Rawlings (1985) yielded much lower and only partly significant positive correlations between divergent tests and P. In 54 Australian adults, Wuthrich and Bates (2001) found no relation between two divergent tests (Wallach and Kogan's (1965) 'pattern meaning' and Torrance's (1974) 'unusual uses') and the revised P scale (Eysenck, Eysenck & Barrett, 1985), but also failed to find relations with NEO-PI-R E, O or A, though the 'unusal uses' test correlated positively in the .30ies with N and C (all self-reports). An unpublished study by Anton, Griepenstroh, Poggenpohl & Rothenpieler (2003) surveyed 78 German adults and found different results for NEO-PI-R self- and peer-reports in relation to the twelve divergent tests of the BIS-4 (Jäger, Süß & Beauducel, 1997; see section 2.1.2): Only N correlated low with a total score, but with negative sign.

Other studies did not or not solely rely on divergent tests when exploring the relations between creativity and these personality dimensions in non-professional samples. Dollinger and Clancy (1993) gave 257 American psychology undergraduates the task to create within the next semester a booklet of twelve photos that should describe their identity. These booklets were rated by four independent raters on a 5-point overall "richness" scale, which was explicitly anchored to include creativity, artistic sensitivity and aesthetic value. Of all self-report NEO-PI scales, only O was a significant predictor of the composite rating (β = .31). Wolfradt and Pretz (2001) found in a sample of 204

German students that, out of the FFM dimensions (measured by NEO-FFI (Costa & McCrae, 1992) self-reports), E and O predicted CPS scores, but only O predicted creativity ratings (sensu Amabile's (1982) Consensual Assessment Technique) of a list of hobbies and a short story written to a picture. In a study by King, McKee Walker and Broyles (1996), 75 American psychology students provided a list of creative accomplishments over a two-year period and completed the verbal scale of the TTCT. The accomplishments were counted and rated for creativity by two raters. The FFM was measured by Big Five Inventory (BFI; John, Donahue & Kentle, 1991) self-reports. While E was correlated .26 with TTCT verbal creativity and A was negatively correlated (-.23) with the reported creative accomplishments, O was the only scale related to both creativity measures (.38 and .47, respectively). McCrae (1993/94) reported a correlation of .53 between Openness to Experience and artistic interests. A study of Martindale and Dailey (1996), however, failed to find an association between O and creativity ratings of a story written to a given topic, the Alternate Uses Test (scored for fluency) and the remoteness of associations given to a list of 100 words in a small sample of 37 male American psychology students. Of the remaining EPQ and NEO-PI scales, only E was significantly related to a composite creativity score. Aguilar-Alonso (1996) let 400 adults fill out the Spanish version of the EPQ, construct a crossword puzzle in a 5 x 5 scheme (scored with one point for every letter belonging to two words) and complete four incomplete drawings (objectively scored for fluency, flexibility and originality). When participants were divided into extreme groups for each of the three EPQ scale (using mean splits), no groups differed significantly on crossword puzzle constructing performance or drawing completion flexibility and originality, but both the group high on E and the group *low* on P were each significantly more fluent on the drawing completion task. Finally, Soldz and Vaillant (1999) showed that, when professional ratings of 132 male Harvard sophomores on 25 traits were classified to fit the dimensions of the FFM, the O factor extracted from these ratings was the only one that predicted a rating of total creative accomplishments (based on a detailed record of achievements, interests and hobbies) in the subsequent 45-year period ($r = .40$). Additionally, only NEO-PI Openness, assessed via self-reports in late adulthood, related significantly (.27) to this creativity rating.

Taken together, the results reviewed in this chapter strongly suggest Openness to Experience as the most likely correlate of a disposition towards creativity. Other candidates, though with less clear empirical support, include Extraversion and

Psychoticism. The other dimension of the Five Factor Model and Eysenck's P-E-N model show no consistent relation. It is striking that the clear majority of these studies measured personality solely with self-report questionnaires. Additionally, all studies reported here were rather atheoretical and only correlational, therefore not able to provide causal explanations. In the next chapter, I will summarize some attempts to integrate what is known about creativity and personality into models and theories.

1.4 Models and theories of a disposition towards creativity

Arguably the most ambitious attempt to integrate diverse findings into a theory of creativity has been conducted by Eysenck (1993, 1995a, b). The central statement of Eysenck's theory is that the genetic, biological and cognitive underpinnings of a normally distributed disposition towards a creative cognitive style ('originality') are the same that underlie Psychoticism. More precisely, Eysenck argues that genes increasing dopamine level and/or sensitivity in the frontal lobe as well as in the mesolimbic dopaminergic system, and genes that decrease serotonin level and/or sensitivity in the serotonergic mesolimbic system will, partly mediated by hippocampal formation activities, lower latent inhibition (Weiner, 1990). Latent inhibition is a preconscious gating mechanism that keeps stimuli previously experienced as irrelevant from entering the focus of attention (Lubow, 1989). A similar phenomenon from cognitive research is negative priming, resulting from experimental paradigms that show higher thresholds for associations with stimuli which previously have been used as distractors. Negative priming is one measure of cognitive inhibition, a state of high cortical activity (sometimes called arousal or drive). Cortical activity is known to be primarily inhibitory. In line with Hull's (1943) "behavioral law", such a state makes dominant stimulus-response-connections even more dominant, leading to reduced behavioral flexibility. Eysenck proposes that a condition of low expression in these three factors (assumingly habitual in individuals with corresponding genetic make-up) leads to an overinclusive cognitive style, marked by a broad, defocused attention, primary process thinking, and flat association hierarchies. Such a cognitive style is not only common in schizophrenic disorders (one extreme pole of the Psychoticism dimension), but shall also be supportive for creative thinking processes.

To understand why the latter shall be the case, we have to take an excursion to the creative process theory on which Eysenck's approach is build. It is Donald Campbell's (1960) theory of blind variation and selected retention, later extended by Simonton (1988) to the Chance-Configuration Theory, and it is on the way to become the predominant theory of the creative process (Simonton, 1999b, c; Cziko, 1995). Campbell's theory, which is also the fundament of evolutionary epistemology in philosophy (Campbell, 1974), is a secondary Darwinian theory, i.e. a theory using Darwin's (1859) theory of biological evolution by natural selection metaphorically. Simply stated, it claims that any creative insight stems from a nonteleological, blind mental combinatory process, which generates chance configurations of mental elements, and whose results are selectively kept and elaborated. Plenty of empirical support from experimental, psychometric and historiometric sources exists (accompanied by a long list of introspective reports from creative genii), most of which are not easily explained by any other theory of creativity. For example, cognitive computer simulations of human creativity as well as artificial intelligence systems that lack a random element are unable to do better than reproducing already known inventions from data limited to the relevant elements. The only objective psychometric measures that relate to creative processes rely on such factors as ideational fluency and remoteness of associations, i.e. manifold and blindness of ideas. And in any field, the creative quality of products is a mere function of quantity, with no sign of a greater probability of success for more experienced producers. For far more detailed reviews and discussions, see Simonton (1998, 1999b, c, d), Cziko (1998), and Eysenck (1995a). However, while the 'retention' part of the theory is rather uncontroversial – such an evaluative step of verification or elaboration was already included in early models of the creative process (Helmholtz, 1896; Wallas, 1926) – the central statement of random variation and mental trial-and-error being fundamental kindled much discussion (e.g. Jensen, 1996; Sternberg, 1998). Most often, criticism roots in two sources, namely (1) a deep preoccupation of the critics against moving creativity out of the scope of intention and volition, and (2) fundamental misunderstandings what is meant by 'blind' or 'chance'. According the first point, Simonton (1999c, d) convincingly argues that having the goal to be creative does not imply having the ability. Even the greatest genii were unable to will producing creative products, a fact that has many historical examples. The second criticism has caused several changes in the naming of the central process (in his most recent publication, Simonton (2003) talks about "constrained stochastic

behavior”). The theory should not be caricaturized as stating that the creative process resembles a monkey writing a Shakespeare play by means of randomly typing on a typewriter (as done by Jensen, 1996). Just like biological evolution, secondary Darwinian processes do not create “hopeful monsters” (resulting from radical and coordinated functional variation), but, step by step, build incrementally on what is already there (Dawkins, 1986), i.e. biologically evolved information-processing adaptations and achieved expertise in the creativity case. Darwinian creativity should also not be interpreted as demanding precise equiprobability for all possible events, which is also not true for biological evolution, where e.g. genetic linkage constraints genetic recombination (Simonton, 1999c). At this point, it is important to emphasize that a Darwinian conceptualization of the creative process does by no means deny individual differences in creativity, nor does it reduce them to differences in expertise and motivation: Any individual difference that alters the amount of quasi-random variation in mental combinatory processes is likely to alter the probability of creative production. This is best described by Austin (1978), who distinguishes four types of chance: Only the first represents “blind luck”, while the other three favor those who are “in motion” (motivation), “prepared” (intelligence and expertise) and “act distinctively” (cognitive style).

Here is the point where Eysenck introduced overinclusive thinking. First, the mere amount of internal and external information entering the attentional focus of an individual with low latent inhibition and negative priming provides masses of rather random input for the creative process. Second, the defocused, associative cognitive state resulting from low cognitive inhibition allows for a large number of simultaneously activated mental representations (Martindale, 1989, 1999), and therefore increases the number of potential combinations. It is noteworthy, however, that creative people do not show a constant pattern of cognitive arousal (which would locate them on Eysenck’s Extraversion dimension). Instead, they show cortical disinhibition only in creative achievement situations, while they appear more inhibited and rather oversensitive in other situations (Martindale, 1989). Eysenck saw such a variable pattern of arousal as a feature of Psychoticism, not Extraversion (a view that was gratefully accepted by Martindale (1993), who noted that he was always unsatisfied with the “paradoxical” relations of creativity and Extraversion in his own studies).

Distilling a creative idea from a blind combinatory process is of course facilitated by processing capacity, mental speed and reasoning ability, all attributable to general

intelligence. Eysenck worships this in conceptualizing creative achievement as a synergistic interaction of several variables, including P and g. Jensen's (1996) review of genius and giftedness, owing much to Eysenck's work, simplifies matters in stating genius being a product of high ability times high productivity times high creativity, and proposing g as the underpinning of ability, P as the underpinning of creativity, and mental energy, a still unclear construct borrowed from Galton (1869), as the underpinning of productivity.

Compelling in its theoretical richness and integration of diverse findings, Eysenck's theory is less convincing on empirical grounds. Especially, studies have found a stronger connection of Psychoticism with creative achievement than with a disposition towards creativity, the latter being unclear at best (see section 1.3). Even worse, while some studies confirmed the association of high Psychoticism and low latent inhibition (Baruch, Hemsley & Gray, 1988; Lubow et al., 1992; De la Casa, Ruiz & Lubow, 1993), Peterson and colleagues (Peterson, Smith & Carson, 2000; Peterson & Carson, 2002) found a much stronger association of latent inhibition with Openness to Experience and (less consistently) Extraversion than with Psychoticism (based on NEO-FFI and EPQ self-reports from student samples). Additionally, they found relations of O, E, and latent inhibition with the CPS. Interestingly, a composite score of O and E was the best predictor of the CPS and latent inhibition. The authors propose an underlying, dopamine-driven exploratory tendency (mediated by a low latent inhibition), with E as its behavioral and O as its abstract-intellectual manifestation (Peterson & Carson, 2002). A study by Wuthrich and Bates (2001), however, contradicted these results by failing to find any relation between latent inhibition and priming on the one hand and self-reports on the NEO-PI-R and the revised Psychoticism scales as well as two divergent tests on the other hand.

Even though the relation between Psychoticism and creativity remains unclear, there is support for the basic mechanism predicted by Eysenck: Carson, Peterson & Higgins (2003) recently found that Harvard students low in latent inhibition had higher originality scores in four of Torrance's divergent tests ($d = .65$), higher CPS scores ($d = 1.06$), and reported more creative accomplishments (effect size in a meta-analysis of two studies: $r = .31$). Comparing 25 distinguished creative achievers with 23 students low in creative achievement showed latent inhibition being able to discriminate between them ($d = .93$). In this sample, a multiple regression of latent inhibition and IQ on creative achievements yielded 30% explained variance and a highly significant interaction of both. The

interaction indicated high IQ combined with low latent inhibition being most favorable for creative achievement. According to the authors, these results give a rational to Guilford's threshold hypothesis. Peterson and colleagues (Peterson & Carson, 2002, p. 1145) concluded: "This would make the individual predisposed to schizophrenia suffering, in principle, from the pathological and possibly synergistic combination of excess experiential, ideational or associational variability, and a decrement in methods of selecting from that excess, while the healthy, open and creative individual would be characterized by a broader gate and careful post-experience selection and culling. So, we have an operationalized quasi-Darwinian approach to the problem of psychosis and creativity (as originally suggested by Campbell (1960) and Simonton (1999[c]))."

Peterson and colleagues' results are highly supportive for major parts of Eysenck's theory, but they strongly suggest a modification in its most central claim: An exchange of P with the common core of O and E. Indeed, out of the lexicographical Big Five personality factors, which are the emerging consensus on a taxonomy of personality descriptive terms across languages (Goldberg, 1990; Ostendorf, 1994), the factor corresponding to O, factor V, is most often interpreted as including creativity as an important aspect (Goldberg, 1994; Ostendorf & Angleitner, 1994), and is sometimes even labeled "Creativity" (Johnson, 1994). Very much in line with the empirical evidence reviewed so far, Ostendorf & Angleitner (1994) suggested from results of an Abridged Big Five Circumplex (AB5C) analysis based on German disposition adjectives that the factor with high positive loadings of factor V and I (Extraversion) markers (V+I+) should be labeled "Creativity" (or "Surgent Mentality"). While this underlines the allocation of creativity in descriptive personality taxonomies, such a phenotypical description lacks explanatory value, since it would be a tautological explanation (Martindale, 1989). Factor V is, however, not identical with Openness to Experience in the NEO-Five Factor Model (Goldberg, 1994). Unlike the descriptive Big Five taxonomy, the FFM is a comprehensive taxonomy of personality *traits*, which can very well be assumed as causal factors. The Five Factor Theory proposed by Costa and McCrae conceptualizes the FFM dimensions as representing fundamental, temperamental, and highly genetic sources of individual differences in personality (McCrae et al., 2000). Such a perspective, while controversial, is partly supported by empirical evidence on a biological link between O/E and latent inhibition, which itself is likely to be influenced by genes moderating serotonin and dopamine level.

Overall, theoretical approaches converge with empirical findings in suggesting general intelligence, Openness to Experience, and, less clearly, Extraversion and Psychoticism as determinants of a disposition towards creativity. All these predictors show moderate to substantial heritabilities (Plomin, DeFries, McClearn & Rutter, 1997; Heath, Eaves & Martin, 1985), so the reasonable next step, undertaken in the next section, will be to ask the same question for creativity itself.

1.5 The etiology of creativity

Inquiries into the heritability of creativity in its highest form – eminence and genius – are even older than the most common behavioral genetic method, the study of twins. In fact, Sir Francis Galton published his famous “Hereditary Genius” in 1869, 13 years before he conducted what is acknowledged as the first twin study. Galton emphasized that genius runs in families. A re-examination of Galton’s data conducted by Bramwell (1948), however, came to the conclusion that this was only the case for judges, but not for any profession normally viewed as creative. Bullough, Boulough and Mauro (1981) concluded in their literature review that creative achievement is rarely inherited for more than one generation. Overall, there is no evidence indicating that creative achievement aggregates within families.

So far, modern behavioral genetic studies of creativity have focused almost exclusively on divergent tests. Additionally, I was unable to identify a single adoption study. Instead, all genetically informative studies on creativity, including the one reported in this thesis, are twin studies. The behavioral genetic twin method decomposes the variance of measured characteristics into shares influenced by genetic (A), shared environmental (C) and unshared environmental (E) sources. This is done on the rational that identical or monozygotic (MZ) twins share an identical genome, while fraternal or dizygotic (DZ) twins share only 50% of their genes on average. Under the assumptions that (1) differences in environmental similarity do not affect differences in pair resemblance of MZ and DZ twins and (2) all three variance sources contribute additively to the observable, phenotypic variance, both of which are well supported (Plomin et al., 1997), the proportion of phenotypic variance attributable to genetic effects (heritability) can be calculated from twin pair intraclass correlations (ICCs) as: $h^2 = a^2 = 2 * (ICC_{MZ} – ICC_{DZ})$ (Falconer formula; Falconer & Mackay, 1996). Additionally, environmental effects can

be estimated as: $c^2 = 2 * ICC_{DZ} – ICC_{MZ}$ and: $e^2 = 1 – ICC_{MZ}$, the latter including error of measurement as long as reliabilities of measures are unavailable (Plomin et al., 1997).
Nichols (1978) reported mean ICCs, weighted for sample size, of .61 for MZ and .50 for DZ twins in a summary of ten studies on divergent test performance published before 1971. They indicate modest genetic influences of 22%, 39% shared environmental influences and 39% non-shared environmental and error influences on the observed variance. Reznikoff, Domino, Bridges and Honeyman (1973) administered a battery of ten creative ability tests to a sample of 63 MZ and 54 DZ adolescent twin pairs. The battery was rather diverse, consisting of five of Guilford's classic divergent tests, a test requiring remote associations to word triplets, a figure preference test, and three test in which responses were rated for originality, including a drawing completion test (the Franck Drawing Completion Test; Anastasi & Schaefer, 1971) similar to the one used in the studies reported in this thesis. Tests were all scored by the same single person. Variance-analytically derived heritability indices yielded a mean heritability index of .14 for the Guilford tests and of .56 for the remote associations. Two of the three tests rated for originality, including the drawing completion test, showed heritability indices below zero (the third, 'Similies', of .39), as did the figure preference test. Calculating variance components from the reported ICCs, the five Guilford tests showed a mean heritability of 41%, a mean shared environmental influence of 38%, and 37% non-shared environmental and error variance. Similarly, estimates were $a^2 = .70$, $c^2 = .08$ and $e^2 = .22$ for the remote associations tests and $a^2 = .68$, $c^2 = .00$ and $e^2 = .41$ for the 'Similies' test. Estimates were not meaningfully calculable for the two tests where ICC_{DZ} were greater than ICC_{MZ}. Grigorenko, LaBude and Carter (1992) tested 60 MZ and 63 DZ adolescent twin pairs from the former Soviet Union with the Russian version of the verbal TTCT scale. ICCs were .86 for MZ and .64 for DZ pairs, yielding estimates of 44% genetic effects, 42% shared environmental effects and 14% non-shared environmental effects plus measurement error. The authors speculated about a relationship between the somewhat higher heritability in their studies compared with Nichols review and expectations of conformity in the communistic system of the Soviet Union, since conformity reduces environmental variances and therefore highlights genetic differences.
In sum, the heritability of performance in classic divergent tests seems to be moderate at best. When the results from the two more recent studies were added with unit weights to the ten studies summarized by Nichols (1978), a rough estimate of 25%

genetic, 38% shared environmental, and 37% non-shared environmental and error influences on classic divergent test variance emerges. It must be noted, however, that divergent test (TTCT) performance within 56 married couples was correlated .33 in a study by Wallinga & Crase (1983). Creativity and verbal fluency are also discussed as characteristics preferred in mate choice (Miller, 2000). Heritability estimates for such tests might therefore be conservative, since they are attenuated not only by unreliability of measurement, but also by assortative mating (which increases DZ, but not MZ twin pair similarity; Plomin et al., 1997). For the same reason, shared environmental effects might be inflated. Still, heritabilities for divergent tests remain lower than those normally found for personality traits, and markedly lower than those found for cognitive abilities. Shared environmental influences, on the other hand, seem to be strong for a cognitive ability measure (Plomin et al., 1997). Results from a twin study by Canter (1973) suggest that the genetic influences on divergent thinking are completely attributable to those of general intelligence: Within-pair resemblance in divergent test performance was very similar for MZ and DZ twins after general intelligence was statistically controlled.

To my knowledge, the only twin study of creativity not based on creative ability tests was published by Waller, Bouchard, Lykken, Tellegen and Blacker (1993). They extracted a general factor from the CPS and calculated ICCs for factor scores of 45 MZ pairs, a MZ triplet, and 32 DZ pairs, all reared apart and unified in adulthood. While the MZ twins showed a moderate resemblance of .54, indicating a heritability of equal amount, the DZ pair correlation was practically zero (-.06). Waller and colleagues concluded from this pattern and the contradictory findings of evidence for a low heritability of divergent tests on the one hand and no evidence for family aggregation of creative achievement on the other that creativity is an emergenic phenomenon. Emergenesis (Lykken 1982; Lykken, McGue, Tellegen & Bouchard, 1992) describes the inheritance of complex higher-order traits, which are synergistically determined by an interaction of multiple, more fundamental, eventually partly heritable traits. Emergenic traits will not run in families, since their components are independently inherited and will be torn apart by sexual recombination. Emergenesis differs from epistasis in that it encompasses the configuration of molar, partly heritable composite traits, not just interactions of alleles at different genetic loci in polygenetic traits. Thus, emergenic traits are heritable (influenced by genes), but it is unlikely that relatives who do not share the complete genetic make-up (i.e. all but MZ twin siblings) show much resemblance. This

is exactly the pattern Lykken and colleagues suggest as indicative of emergenesis in twin studies: Non-negligible MZ and negligible DZ intra-pair resemblance. “What we suggest now is that perhaps many complex human psychological traits (e.g., many of the idiosyncrasies of personal style that we have observed in twins), as well as traits like extraversion; the ability to stop reacting to a meaningless repeating stimulus (*habituation*); more familiar traits like leadership, artistic ability, selling ability, teaching ability, creativity, parenting ability – and also many examples of human genius – are emergenic traits. Because these attributes do not tend to run in families, the possibility of their having a genetic basis has been overlooked. As we have seen, we will not discover the emergenic character of such traits unless we study twins. Until this idea is more broadly accepted, we will not *believe* what we discover unless we study twins reared apart.” (Lykken et al., 1992, p. 1569; italics original, underlinings added).

An emergenic view of the etiology of creativity seems to be the emerging consensus in the literature (e.g. Martindale, 1999; Simonton, 1999b). While surely appealing for creative achievement and genius, where synergistic interactions of determinants are already included in theories, such a perspective is rather odd for a more fundamental disposition towards creativity. This is especially the case because, as stated at the end of the last section, the theoretically and empirically identified determinants of such a disposition are moderately to highly heritable. Thus, an emergenic inheritance pattern would only emerge if indeed *several* of these determinants are *necessary* conditions for a disposition towards creativity. This conclusion would be premature given the empirical evidence available to date, since only components of creativity have been studied with behavioral genetic methods so far. There exists no such study of molar creativity. Multivariate behavioral genetic analyses of the links between dispositional creativity and its determinants would also be helpful, but are completely absent from the literature. Though a need for more research is expressed in many areas, it seems truly urgent here.

1.6 Aims and hypotheses of the present study

1) Consensus on a common person's dispositional creativity

Following the consensual definition of creativity (Amabile, 1982), it is hypothesized that independent raters will agree on a person's creativity. Assuming a general, dimensional, and relatively stable disposition towards creativity, this should be the case for people from the normal population, who are not necessarily distinguished creative achievers in any field. It should also hold across measurement times, kinds and amount of information about the person, and degrees of acquaintanceship.

2) Dispositional creativity and intelligence

Based on previous studies, but contrary to the certification hypothesis, it is assumed that a disposition towards creativity will show a low to moderate, but significant relation to general intelligence. Following Cattell (1971), a similar relation is expected to the facets of fluid and crystallized intelligence, with that to fluid intelligence being stronger than that to crystallized intelligence, since fluid intelligence should explain most of the link between crystallized intelligence and creativity. Finally, contrary to the weakly proven threshold hypothesis, the relation of general intelligence and dispositional creativity is expected to be linear, with similar correlations of both variables across the whole intelligence spectrum.

3) Dispositional creativity and personality

Out of the broad personality dimensions of the Five Factor Model and the P-E-N Model, the literature suggests strong relations with Openness to Experience and weaker relations with Extraversion for a disposition towards creativity. Research on latent inhibition suggests a common core of both as especially important, a possibility that will be explored. An alternative hypothesis would be a strong relation of dispositional creativity with Psychoticism. Both will be compared in the main study. In any case, personality dimensions should be incremental to general intelligence in the prediction of dispositional creativity. To test configurational theories of creativity, the predictive value of personality x general intelligence interactions will be tested for Openness to Experience, Extraversion, an Openness-Extraversion composite, and Psychoticism[1].

[1]: Eysenck (1995b) did only predict synergistic effects of Psychoticism and intelligence on creative *achievement*. The conceptualisation of *dispositional* creativity in this thesis comes of course closer to what Eysenck called trait creativity or originality. Therefore, only a direct effect of Psychoticism would be expected. However, if (high) Psychoticism is taken as a possible proxy for (low) latent inhibition, then the results of Carson et al. (2003) would suggest the possibility of a synergistic effect.

4) Necessity of personality and intelligence factors for dispositional creativity

Since the personality and ability dimension that will be related to dispositional creativity in this study are assumed to be more biologically basic and are partly suggested to be causal in theoretical approaches, it is hypothesized that statistically controlling the variance of more fundamental personality dimensions and general intelligence will markedly decrease the relationship between different measures of dispositional creativity and dissolve their structure.

5) Genetic and environmental influences on dispositional creativity

The amount genetic, shared environmental and non-shared environmental effects on a disposition towards creativity will be estimated. Previous behavioral genetic studies focused on single components of creativity and yielded different results for different components. This is the first behavioral genetic study of a molar creativity measure, perceived dispositional creativity.

6) Genetic and environmental links between dispositional creativity and its predictors

To date, not a single study has applied multivariate behavioral genetic designs to explore the overlap of genetic and environmental effects on creativity and its assumed determinants or the mediation of observed phenotypical correlations between creativity and related constructs by genetic and environmental links. This gap will also be filled with the present thesis.

Before all of these questions and aims will be tackled in the main study, a pilot study is reported, which was conducted to explore and validate one of the measures used in the main study.

2. Pilot study: The T-88 as a measure of creativity

Aim of the pilot study was to test the reliability of the T-88 (Cattell & Warburton, 1967), a drawing completion test which is also used in the main study, as a measure of creativity, and to compare it with classic divergent tests. This was important, since (a) the T-88 was not constructed as a measure of divergent thinking or creativity, and (b) it was not administered in a standardized situation, but self-administered by the participants at home in both studies. It is hypothesized that (1) the T-88, when administered this way, can still be reliably scored by different raters for originality and elaboration, even when rated rather subjectively, (2) both scores are related, but not identical (i.e. raters are able to discriminate the dimensions), and (3) both scores will show modest, but significant relations to classic divergent tests, administered in a standard test situation and objectively scored for fluency and flexibility. It is important to remark that this pilot study can only be a very weak attempt to validate the T-88 as a measure of true creative ability, since the use of divergent tests as such a criterion has been strongly criticized (Brown, 1989; Hocevar & Bachelor, 1989).

2.1 Method

2.1.1 Sample

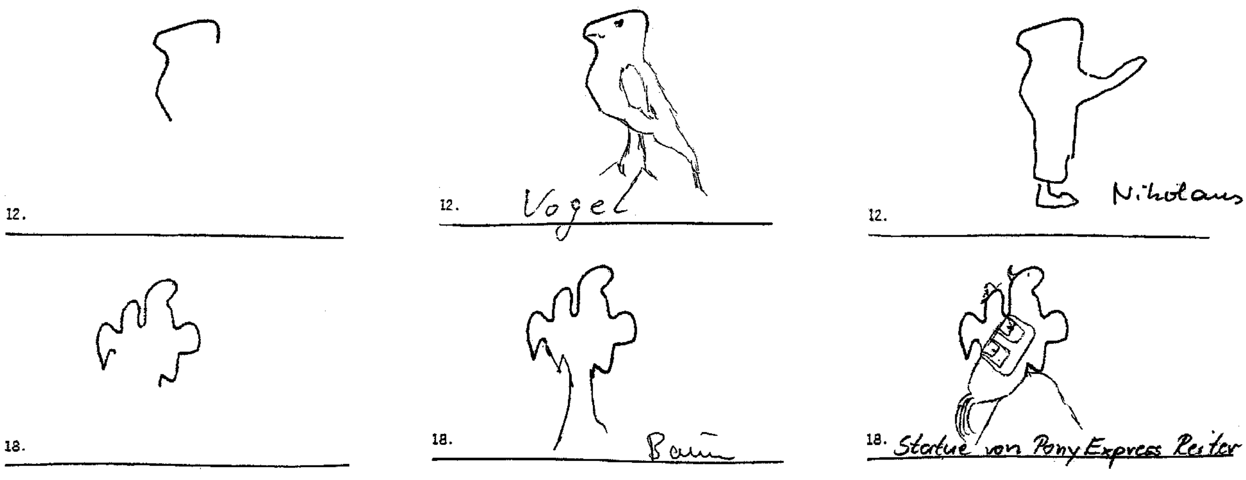
As part of an empirical practical, four students[2] of the University of Bielefeld recruited 78 subjects (48 females, 28 males, two missing data) as voluntary participants for a more comprehensive study (see Anton, Griepenstroh, Poggenpohl & Rothenpieler, 2003), which included this pilot study. Eight subjects where later excluded because of missing data, leading to a final sample of 70 subjects for the pilot study (44 females, 25 males, one missing data). Age of subjects ranged from 18 to 58 years (M = 27.1, SD = 9.4, median = 25.0, one missing data). The majority of subjects (65.4 %) were students from various faculties (mostly psychology), the others were friends or relatives of the students and came from various backgrounds. None of the subjects were paid for participation, but all were offered a personality profile based on a measure not further discussed in this pilot study. Additionally, students of psychology received certificates of their participation, which they required for their Diploma.

[2]: I would like to thank Friederike Anton, Julia Griepenstroh, Henrike Poggenpohl and Sandra Rothenpieler for collecting the data of this pilot study.

2.1.2 Materials

T-88: The T-88, here administered in its German version (Häcker, Schmidt, Schwenkmezger & Utz, 1975), is a subtest of the Objective Test Battery (Cattell & Warburton, 1967) and was originally constructed as a measure of Cattell's exvia factor. It consists of eighteen incomplete line drawings (see figure 1 for examples of items and responses and the appendix (section 6.1) for the whole test). The subjects are instructed to complete and name the drawings in any way they like within a four minutes time limit.

Figure 1:
Exemplary Items and Responses of the T-88



The T-88 shows remarkable resemblance to the Franck Drawing Completion Test (FDCT; Franck & Rosen, 1949), a test consisting of 36 line drawings very similar to those of the T-88. It was originally constructed as a projective measure of a person's sex adjustment or concern over his or her sex role. Barron (1958), however, used ratings of FDCT responses as a measure of "creative originality" and Yamamoto (1964) used six FDCT drawings (and their titles) as a test of divergent production sensu Guilford (1967a). Torrance later developed a subtest of the TTCT (Torrance, 1966) based on this work. The first twelve FDCT drawings were administered to 800 high school students by Anastasi and Schaefer (1971; Schaefer, 1970). They showed that rating the responses for originality, elaboration and asymmetry, but not for abstraction or scoring them objectively for the number of different content categories used (flexibility), differentiated creative from non-creative students (qualifying as such in both

teacher nominations and Guilford's Alternate Uses and Consequences tests) in both boys and girls and in both arts and science students.

The present study adapted Anastasi and Schaefer's scale format and scoring instructions (see also Schaefer, 1969). The T-88 responses were rated itemwise (with item order randomized) by three independent raters (two female, one male) according originality (5-point Likert-type scale ranging from 1 (very poor) to 5 (very clever or unusual idea)) and elaboration (3-point Likert-type scale ranging from 0 (not identifiable or arbitrary) to 2 (identifiable and detailed or decorated)). Rater instructions included definitions of originality and elaboration, detailed anchors for each scale point of both scales, sensibilisations to rater biases, and emphasizes to evaluate form as well as content and discriminate elaboration from drawing ability (see the appendix (section 6.2) for the original German instructions). Additionally, raters were provided with a list of the most common responses for each item, including frequencies in percentages (see section 6.3). These lists were based on frequency counts of response content for each item in 278 randomly selected test sheets from the main study sample and included all response contents mentioned in more than five percent of the cases (following Vernon, 1971, p. 252). The scale definitions and response baselines were thought solely as an orientation for the raters, who were explicitly advised to use them that way, i.e. to maintain their subjective impression in their ratings. Note that this scoring procedures differs from those most widely used for divergent tests (e.g. by Guilford (1967a) or Torrance (1974)), who emphasize reduction of subjectivity by means of objectively counting response frequencies (originality) or included features (elaboration).

The present scoring of the T-88 further deviates from that of most classical divergent tests by excluding ideational fluency (number of responses given). While Yamamoto (1964) and Torrance (1966) scored their FDCT adaptations for fluency, Torrance already mentions the limited usefulness of such a score in this test (Torrance, 1966, pp. 14-15), leading Anastasi and Schaefer (1971) to drop fluency. But since they still calculated total scores for the scoring dimensions used in their study by summing over item scores, they included an indirect fluency effect, because a greater number of responses easily inflates such sum scores. The present study went further and, in line with Hocevar's (1979a) suggestion (discussed in section 1.2) controlled for fluency by averaging item scores for originality and elaboration. Subjects were not excluded for failing to complete a critical amount of items, since (a) such a procedure is likely to be

an overcontrolling of fluency and might induce range restriction, and (b) no subject completed less than one third and only one completed less than half of the items.

BIS-4: The ‘Berliner Intelligenzstruktur-Test’ (Berlin Intelligence Structure Test, BIS-4; Jäger, Süß & Beauducel, 1997) is a multifactorial German intelligence test based on the well-acknowledged Berlin Intelligence Structure Model of Jäger (1982, 1984). This model is hierarchical, because it includes the g factor of intelligence (Spearman, 1904) on its highest level as well as a subordinated bimodal classification of abilities into three content (figural, verbal, numerical) and four operation (processing speed, remembering ability, imaginativeness, processing capacity) aspects. The aspects are assumed to underlie all intellectual abilities, but with markedly different weightings. The BIS-4 assesses all twelve ability aspects in this 3 x 4 matrix with a total of 45 different subtests (three to five per cell) and allows calculating a g value, too. In this pilot study, only the twelve subtests of the imaginativeness scale (abbreviated E for German “Einfallsreichtum”) in all three content aspects are used. These subtests resemble classic divergent tests, but were chosen by the test authors to require problem-oriented ideational flexibility (i.e. imaginativeness) and to be easily and objectively scoreable. They are therefore scored for number of mentioned categories (given in the manual) where possible (flexibility, five tests), and for number of correct responses (fluency) where this has not been objectively possible so far (seven tests). Because more complex and more subjective to score, originality and elaboration measures were not included in the E-scale. This was the rational to call it a measure of imaginativeness instead of creativity (Jäger et al., 1997, p. 32). To provide a more differentiated picture for analyses on subtest level, all subtests scored for flexibility were additionally scored for fluency in this study. However, following the manual, only the flexibility scores were included in calculations of the E scores in these cases. Table 1 lists the E-scale subtests with their scoring in the BIS-4, as well as a short description of them.

Table 1
Subtests of the BIS-4 E Scale

Subtest	Name	Scoring	Description	M	SD
figural:					
ZF	continue signs	flexibility	Completing identical line drawings to different real objects.	102.74	10.72
LO	layout	fluency	Creating graphical emblems for a shop advertisement.	91.20	10.75
ZK	combine signs	fluency	Combining four geometric figures to figural composites.	90.50	10.03
OJ	object design	flexibility	Combining four geometric figures to various real objects.	98.20	11.43
verbal:					
MA	Masselon	fluency	Inventing sentences including three given nouns.	100.72	10.14
AM	alternate uses	flexibility	Listing different possible uses for a given object.	96.59	9.29
EF	traits-abilities	flexibility	Listing traits unfavorable for a given occupation.	100.76	8.83
IT	insight test	flexibility	Listing reasons for a given social behavior.	102.73	10.24
numerical:					
TN	telephone numbers	fluency	Constructing easy-to-remember telephone numbers.	98.70	11.78
DR	divergent calculations	fluency	Producing arrays of numbers that fit a given equation.	91.21	8.45
ZR	number riddle	fluency	Filling number patterns into a geometric scheme.	92.32	8.87
ZG	number equations	fluency	Producing equations from given numbers and operations.	93.84	9.34

2.1.3 Procedure

First, the E-scale subtests of the BIS-4 were administered to the subjects either in individual (25%) or group testings of 2-5 participants (75%) on scheduled occasions. After the BIS-4 testing, subjects received an envelope including the T-88 and further personality measures not discussed in this thesis, and were asked to return them within the next weeks after completing them at home. Subjects received a certification of their participation on return of the materials and a personality profile a few weeks later.

Note that administering the T-88 in this manner deviated markedly from the standard procedure for ability test. Though, ever since Wallach and Kogan (1965), more relaxed and less evaluative test conditions have been suggested as favorable for divergent tests. Ferris, Feldhusen and van Mondfrans (1971) compared the predictive validity of divergent tests administered under four different conditions for academic achievement in 5th, 8th and 11th grade pupils, and found that those tests filled out at home during spare time and without time limit did best. Vernon (1971), in a review and study of administration effects on divergent tests, concluded: “Our major finding is, then, that divergent test scores obtained under relaxed conditions have generally richer psychological meaning than those obtained under more formal, test-like conditions.” The T-88 instructions, on the other hand, insist minding a 4 minutes time limit for the 18 items, and visual inspections of the test sheets (especially of the reported time used) indicated that most subjects indeed paid attention to it. While there is no reason to

believe that such a de-relaxation of test conditions should have detrimental effects on test scores, uncontrollable individual differences in keeping the time limit might introduce error variance, at least in the number of items completed. This gives a second rational for using item means instead of item sum scores for the analyses.

2.2 Results

2.2.1 Reliability analyses

Table 2 shows the means and standard deviations of the elaboration ratings for each of the three raters, as well as their intercorrelations (ranging from .70 to .80). These values were evaluated as high enough to sum all three raters to a composite score. The composite yielded a satisfactory interjudge agreement (ICC 3, 3 = .72, indexed according to the taxonomy of intraclass correlations suggested by Shrout and Fleiss, 1979; Cronbach's α = .89).

Table 2
Pearson-Correlations of the Elaboration-Ratings

Elaboration	Rater 1	Rater 2	M	SD
Rater 1	-	-	1.08	.17
Rater 2	.76**	-	1.05	.23
Rater 3	.70**	.80**	.94	.26

Note: * p < .05, ** p < .01 (both two-tailed), N = 70.

Means and standard deviations as well as rater intercorrelations of the originality ratings are listed in table 3. Because they were even better than those of the elaboration ratings (.82 to .87), they were also summed to a composite, which had good reliability (ICC 3, 3 = .83, Cronbach's α = .94).

Table 3
Pearson-Correlations of the Originality-Ratings

Originality	Rater 1	Rater 2	M	SD
Rater 1	-	-	2.93	.36
Rater 2	.84**	-	1.84	.38
Rater 3	.82**	.87**	2.38	.44

Note: * p < .05 **, p < .01 (both two-tailed), N = 70.

Pearson product-moment correlations between elaboration and originality ratings were .61 ($p < .01$), .44 ($p < .01$), .27 ($p < .05$) and .47 ($p < .01$) for raters 1, 2, 3, and rater composite, respectively.

Table 4 gives psychometric properties for the BIS-4 total imaginativeness (E) scale, as well as for the figural, verbal, and numerical E subscales. Reliability (Cronbach's α) was satisfactory for the total scale (.79), but was only modest (.50 to .62) for the subscales. However, total scale internal consistency equals the value reported in the manual (.77), and the test authors argue that Cronbach's α is a coefficient of very limited usefulness for the heterogeneous BIS-4 (Jäger et al., 1997, p. 37). Mean inter-item and part-whole corrected item-total-correlations were good. Scale mean of total imaginativeness was slightly lower than in the normative sample reported in the manual (1200; standard deviations for all scales and means for subscales were not reported). The last two columns of table 1 (p. 27) show means and standard deviations for the subtests of the E scale. None of them differed markedly from the normative values (M = 100, SD = 10).

Table 4
Psychometric Properties of the BIS-4 E-Scale and Subscales

Scale	Number of items	Cronbach's α	r_{ii}	Number of items with corrected $r_{it} < .20$	M	SD
E	12	.79	.24	0	1160.87	65.58
E (figural)	4	.57	.25	0	382.21	28.47
E (verbal)	4	.50	.20	0	404.41	23.59
E (numerical)	4	.62	.29	0	376.12	25.98

Note: N = 70, r_{ii} = mean inter-item correlation, r_{it} = item-total correlation.

Visual inspections of histograms indicated that neither the T-88 nor the BIS-4 scores deviated from a normal distribution.

2.2.2 Correlational analyses

Biserial correlations of T-88 and BIS-4 E scales with subjects' sex and Pearson correlations with age are shown in table 5. None of the correlations with age reached significance, but elaboration correlated positively (.29) with sex, indicating women being more elaborated in their T-88 drawings, and verbal imaginativeness correlated negative (-.24) with sex, indicating higher values for men.

Table 5
Correlations of the T-88 and the BIS-4 with Sex and Age

	T-88 elaboration	T-88 originality	BIS-4 E	BIS-4 E (figural)	BIS-4 E (verbal)	BIS-4 E (numerical)
Sex	.29*	.01	-.20	-.14	-.24*	-.13
Age	-.09	.07	.09	.02	.12	.09

Note: * p < .05, ** p < .01 (both two-tailed), N = 69.
Males are coded as 1, females as 2.

In the upper part of table 6, correlations of elaboration and originality with the total E scale as well as the content-specific subscales are shown. Elaboration correlated positively with all scales except verbal imaginativeness. However, none of these correlations reaches significance. Originality shows low but significant associations with all but numerical imaginativeness, which is still positive.

Table 6
Correlations of the T-88 with the BIS-4 E-Scale

	T-88 elaboration	T-88 originality
Scales:		
BIS-4 E	.14	.25*
BIS-4 E (figural)	.19	.26*
BIS-4 E (verbal)	-.01	.26*
BIS-4 E (numerical)	.15	.11
Subtests:		
figural:		
ZF ('continue signs'; flexibility)	.23	.34**
ZF ('continue signs'; fluency) #	.15	.41**
LO ('layout'; fluency)	.15	.25*
ZK ('combine signs'; fluency)	.08	.08
OJ ('object design'; flexibility)	.06	.03
OJ ('object design'; fluency) #	.14	.13
verbal:		
MA ('Masselon'; fluency)	.09	.18
AM ('alternate uses'; flexibility)	.09	.12
AM ('alternate uses'; fluency) #	.02	.14
EF ('traits-abilities'; flexibility)	-.04	.27*
EF ('traits-abilities'; fluency) #	-.07	.21
IT ('insight test'; flexibility)	-.16	.10
IT ('insight test'; fluency) #	-.29*	-.02
numerical:		
TN ('telephone numbers'; fluency)	.12	.06
DR ('divergent calculations'; fluency)	-.01	-.10
ZR ('number riddle'; fluency)	.08	.27*
ZG ('number equations'; fluency)	.19	.15

Note: # not included in the E-scales, * p < .05, ** p < .01 (both two-tailed), N = 70.

The lower part of table 6 gives correlations between T-88 scores and E scale subtests. Of these 34 coefficients, only two reached significance on the one percent α level, both between subtest ZF (flexibility and fluency score) and originality. Because of multiple testing, results significant on a less conservative α level were ambiguous to interpret. Of the remaining 15 originality correlations, 13 were in the expected direction, but only three were significant on five percent α level. Five of the 17 correlations between subtests and elaboration were not in the expected direction, one of them (IT fluency) even significant on the five percent α level. No other correlation with elaboration reached significance.

2.3 Discussion

Consistent with hypothesis one, completed T-88 drawings proved to contain enough useful information to allow raters to make intersubjectively reliable judgments about their originality and elaboration. In line with hypothesis two, both dimensions were moderately related, but discriminable. Partially disproving hypothesis three, however, only the originality ratings shared a small, but significant amount of variance with the imaginativeness scale of the BIS-4. IT stem from significant relations with the figural and verbal, but not the numerical aspects of imaginativeness - a reasonable result, since originality of drawings (figural aspect) as well as titles (verbal aspect) affected T-88 scores. Associations are especially strong with the subtests most similar in content (ZF, LO). These results indicate some support for convergence despite different test situations, but question the generality across content aspects of the creative abilities measured by the T-88. All in all, validity results seem disappointing at first glance, especially for elaboration.

We have to keep in mind, however, that the T-88 and the BIS-4 E subtests are scored very differently. Fluency is known to be the determining factor in classic divergent tests (Hocevar, 1979a, b; see section 1.2) and serves this function also in the E scale (mean correlation between flexibility and fluency scores of subtests for which both were available was .74 in this sample). These kinds of tests do only measure some aspect of real creative ability, and, as mentioned above, do not qualify as a creativity criterion. Indeed, the criterion validities of the E scale reported in the manual are not very convincing (Jäger et al., 1997, pp. 45-46). Since the T-88 scores used here were

controlled for fluency, the results are still remarkable, tentatively indicating that what is shared between these operationalizations of originality and imaginativeness might be true creative ability.

What can be concluded, then, is that elaboration and originality of T-88 responses can be reliably rated, are distinguishable, but related dimension, and do not measure what classical divergent tests measure, with only originality showing some association to that aspect. The results Anastasi & Schaefer (1971) received with a similar measure, on the other hand, turn optimistic that the T-88 is a valid measure of creativity. The clearest limitation of the T-88 usage in this study is its uncontrolled time limit, reducing test objectivity and therefore reliability and validity. However, the pilot study showed no hint to markedly detrimental effect of the administration procedure used, suggesting some robustness of the T-88 to it.

3. Main study: Creativity in BiLSAT and GOSAT

3.1 Method

3.1.1 Sample

The main study of this thesis is based on the Bielefeld Longitudinal Study of Adult Twins (BiLSAT) and the German Observational Study of Adult Twins (GOSAT). The BiLSAT register was started in 1993 by Alois Angleitner and Jan Strelau with over 1,100 pairs of adult twins who voluntarily reacted on announcements in the media and twin clubs. The register is population-based and very heterogeneous. By now, these twins were surveyed three times by mail (BiLSAT), and a subsample of 300 twin pairs was invited to the University of Bielefeld, one pair per day, for intensive assessment (GOSAT) (Spinath, Angleitner, Borkenau, Riemann & Wolf, 2002).

The present study draws on data from BiLSAT waves II. and III. as well as GOSAT. Not all twins completed all measure used in it, since (a) the BiLSAT sample size changed over time due to both attrition and inclusions of twins being added to the register at a later stage, and (b) only a subsample participated in GOSAT. To increase statistical power, each analysis was conducted with the largest possible sample size, yielding different subsamples in different analyses. I will therefore report sample descriptions and measure reliabilities for the maximal total sample used as well as for the minimal core sample that completed all relevant measures (on which analyses on highest aggregation level were based).

3.1.1.1 Total sample

In total, data from 2,608 individuals (622 male (23.8%), 1842 female (70.6%)) was used. Age at the last wave ranged from 21 to 74 (M = 39.0, SD = 12.9, median = 36.1). These subjects belonged to 742 monozygotic (MZ), 289 same-sex dizygotic (DZss), and 226 opposite-sex dizygotic (DZos) pairs of twins. Subject’s sex was not available for 144 cases, age was even missing for 1452 cases and zygosity could not be reliably determined for 320 individual twins. However, except for some basic analyses at the very beginning, all further steps were based on data corrected for age and sex effects,

therefore only conducted with those subjects for whom these data were available. This lead to a sample of 1,155 individuals (246 male (21.3%), 909 female (78.7%)), at the last wave in the age of 21 to 74 (M = 39.0, SD = 12.9, median = 36.1), who belong to 352 MZ pairs, 179 DZss pairs and 42 DZos pairs. The zygosity of 9 individual twins was unclear.

3.1.1.2 Core sample

Complete data for all measures used in this study was available for 267 subjects (55 male (20.6%), 212 female (79.4%)) who were at the age of 21 to 70 (M = 38.4, SD = 12.8, median = 34.1) at last wave of assessment. They combined to 53 MZ and 43 DZss twin pairs, leaving a residual of 38 individual MZ and 37 individual DZ twins, whose co-twin failed to complete all relevant measures.

Comparisons of total and core sample descriptives indicated that age and sex structure was similar.

3.1.2 Materials and procedure

The present study uses only a small part of the measures administered to the twins. See Spinath et al. (2002) for a detailed list of all measures.

3.1.2.1 Measurement point 1: II. BiLSAT wave

In 1995, a battery of self-report questionnaires and two shorter batteries of peer-report questionnaires were mailed to the twins of the register. They were asked to fill out the self-report questionnaires and let themselves be rated on the peer-report questionnaires by two peers who favorably knew one, but not the other, twin of the pair very well. Postage for returning completed questionnaires was paid by the researchers. Three measures administered in this wave are of interest for the present study:

EPQ-RK: The short version of the revised Eysenck Personality Questionnaire (EPQ-RS; Eysenck & Eysenck, 1991) in its German adaptation (EPQ-RK; Ruch, 1999), a measure of Eysenck's P-E-N model of personality, was administered to the twin and in a third-person version to both peers. Only the Psychoticism (P) scale of the EPQ-RK was used herein. It asks the subject to answer 14 questions about his or her personality with 'yes' or 'no'. Exemplary items are "Are good behavior and tidiness important for you?" or "Are you strongly affected by seeing children or animals suffer?".

UNIPOL and BIPOL adjective lists: Both the UNIPOL and BIPOL adjective lists stem from the German taxonomy of personality-descriptive terms (Angleitner & Ostendorf, 1994; Ostendorf, 1994). The UNIPOL list includes 100 unipolar adjectives and asks the subject to indicate how well each of the adjectives describes him or her on a 5-point Likert scale (ranging from 1, 'not at all fitting', to 5, 'very fitting'). The BIPOL list consists of 119 bipolar adjective pairs with 6-point Likert scales (ranging from -3 to +3), which should be used by the subjects to indicate where on the dimension marked by the adjectives he or she locates him- or herself. While the UNIPOL list was only given to the twins, the BIPOL list was also filled out by both peers. Only the adjective 'creative' of the UNIPOL list and the pair 'uncreative – creative' of the BIPOL list are of interest for the present study.

3.1.2.1 Measurement point 2: GOSAT

Over a two-year period between 1995 and 1997, 300 BiLSAT twin pairs were studied, pair by pair, for a whole day at the University of Bielefeld (see Spinath et al. (1999) for details). Co-twins were separated during the whole GOSAT assessment day. Out of the multitude of measures applied in GOSAT, two intelligence tests and video-based personality ratings are of relevance for this thesis:

APM-20: The German version of Raven's Advanced Progressive Matrices (Raven, 1958; Kratzmeier & Horn, 1974) was administered with a 20-minutes time limit. As shown by Frearson and Eysenck (1986), the 20-minutes version is highly correlated with the standard 40-minutes version.

LPS-K: The Leistungsprüfsystem (Horn, 1962) is a highly reliable German intelligence test developed to measure Thurstone's (1938) primary mental abilities. In GOSAT, the short form of the test (Sturm & Willmes, 1983) was applied, consisting of seven subtests (number 1, 2, 4, 5, 9, 10, and 12; 40 items each) measuring verbal comprehension, reasoning, word fluency, space, and closure.

Neubauer, Spinath, Riemann, Angleitner and Borkenau (2000) calculated two oblique factors resembling Cattell's (1963, 1971) fluid (g_f) and crystallized (g_c) intelligence from the LPS-K data of the GOSAT sample, as well as a factor of general intelligence (g) sensu Spearman (1904) from both the LPS-K and APM-20 results. The present study will only use these three factors based on the factor values of the Neubauer et al. study.

Video ratings: During their GOSAT day, each twin was, separately from his co-twin, videotaped in 15 assessment-center-like situations. These were (in timely order): (1) introducing oneself, (2) arranging three photographs in a meaningful order and telling an interesting story to it, (3) telling a dramatic story to each of three pictures from the Thematic Apperception Test (TAT; Murray, 1943), (4) telling a joke, (5) persuading an 'obstinate neighbor' to turn down her music after 11 PM in a telephone role-play, (6) refusing a request for help by a friend who just had a car accident in a second telephone role-play, (7) introducing oneself to a stranger (actually a confederate) after the confederate introduced herself, (8) recalling objects one has just seen in a waiting room, (9) solving a complex logical problem, while the confederate from setting 7 solves the same problem in enormous speed, (10) introducing a different confederate to the experimenter, (11) inventing a definition for a neologism and provide arguments for why that definition would be appropriate, (12) rigging up a high and stable paper tower within 5 minutes, using only scissors, paper, and glue, (13) reading 14 newspaper headlines and their subtitles aloud, (14) describing multiple uses of a brick pantomimicly, and (15) singing a song of one's choice. Videotaped sequences of the situations had an average duration of between one and twelve minutes, and summed up to about 60 minutes per twin. Each twin's personality was rated on base of the videos by four independent judges per situation (i.e. 15 x 4 = 60 independent judges per twin) on 35 bipolar adjective pairs, using computerized 5-point Likert scales. Only one of these adjective pairs, 'creative – uncreative', will be dealt with in the following. Borkenau, Riemann, Angleitner and Spinath (2001), whose article also gives further details on GOSAT and

the video ratings, calculated an aggregate score of the 60 ‘creative – uncreative’ ratings per twin, which had an excellent interjudge reliability (ICC 1, 60 = .90). This aggregated score was used in analyses reported below.

3.1.2.3 Measurement point 3: III. BiLSAT wave

Paralleling the procedure of the second wave described above, all twins of the register were mailed further sets of questionnaires for self- and two peer-reports between 2000 and 2001. Two of these measures are of interest here:

NEO-PI-R: The revised NEO Personality Inventory (Costa & McCrae, 1992) in its German adaptation (Angleitner & Ostendorf, 2003) is a measure of the NEO-Five Factor Model trait domains of Neuroticism (N), Extraversion (E), Openness to Experience (O), Agreeableness (A) and Conscientiousness (C). The five global scales consist of 48 items each, divided into six eight-item-long facet scales, totaling to 240 items. For each item, the value of a statement like “I often feel tense and nervous” or “I like parties with many people” as a description of one’s personality shall be indicated on a 5-point Likert scale (ranging from 1, ‘not at all fitting’, to 5, ‘very fitting’). Only global scales will be analyzed in this study. Apart from the twins themselves, two peers per twin rated them using a version of the NEO-PI-R formulated in the third person.

T-88: Administration, scoring and raters of the T-88 were identical to the pilot study (chapter 2). Since this time over 800 response sheets had to be rated, they were randomly assigned to six booklets, which the raters worked through in randomized order. Only 1.45% of the subjects completed less than one third of the T-88 items, and only 5.19% completed less than half of the items. Therefore, again no subjects were excluded for having completed too few items.

3.1.3 Zygosity determination

For 283 GOSAT twin pairs, zygosity diagnosis was conducted using either blood or salvia samples. The procedure applied for 248 of these twin pairs was based on five highly polymorphic dinucleotide repeat marker loci (Becker et al., 1997), with the probability of misclassifying DZ as MZ twins being less than 0.9%. For further 35 of these twin pairs, zygosity determination relied on semiautomated genome mapping on ten highly polymorphic dinucleotide repeat marker loci, with an according error rate of less than 0.1%. The classification of the remaining GOSAT and BiLSAT pairs was based on questionnaire measures (Oniszczenko, Angleitner, Strelau & Angert, 1993) or physical similarity data, with an estimated error rate of 7.0%.

3.2 Results

3.2.1 Reliability analyses

Tables 7 and 8 give means, standard deviations and intercorrelations for the three T-88 raters on the two rating dimensions (elaboration and originality). Average rater intercorrelation was .80 for elaboration and .81 for originality, both evaluated as high enough to sum raters to composites. For both composites, interrater reliability was good (elaboration: ICC 3, 3 = .76, Cronbach's α = .90; originality: ICC 3, 3 = .80, Cronbach's α = .92). Correlations between elaboration and originality were .70, .53, .47 and .61 for rater 1, 2, 3 and rater composite, respectively (all $p < .01$).

Table 7
Pearson-Correlations of the Elaboration Ratings

Elaboration	Rater 1	Rater 2	M	SD
Rater 1	-	-	1.03	.20
Rater 2	.82**	-	.97	.28
Rater 3	.73**	.83**	.81	.32

Note: * p < .05, ** p < .01 (both two-tailed), N = 828.

Table 8
Pearson-Correlations of the Originality Ratings

Originality	Rater 1	Rater 2	M	SD
Rater 1	-	-	2.79	.37
Rater 2	.78**	-	1.80	.41
Rater 3	.77**	.86**	2.20	.47

Note: * p < .05 **, p < .01 (both two-tailed), N = 828.

Tables 9 shows results from reliability analyses of the NEO-PI-R and EPQ-RK, and means and standard deviations of the LPS-K and the APM-20, for the total study sample. Table 10 contains the same results for the core sample of 267 individuals. Overall, reliabilities were good for all NEO-PI-R global scales. Internal consistencies ranged between .85/.87 (A) and .93 (E) for self-reports and between .84 (O) and .93 (E) for peer-reports. These values, as well as all NEO-PI-R means and standard deviations, were very similar to those Angleitner and Ostendorf (2003) reported for the German normative sample. Mean inter-item correlations seemed rather low and number of items with critical part-whole corrected item-total correlations rather high, but such values are expectable for long, heterogeneous scales measuring broad constructs.

For the EPQ-RK P scale, internal consistencies were rather low, especially for the self-reports (.59/.59). Indeed, self-report values were markedly lower than those in a normative sample reported by Ruch (1999), which ranged from .72 to .76. These values were critical, even though the P scale is conceptualized as heterogeneous and strongly varying in item difficulties, rendering Cronbach's α an inadequate index for it (Ruch, 1999). Means and standard deviations of self-reports were also somewhat lower than those reported by Ruch (M = 3.37 and SD = 2.54 for the total normative sample). No such normative values were available for peer-reports. Corresponding to these results, mean inter-item correlations were rather low and number of items with low corrected item-total correlations rather high for a 14-item scale, especially for self-reports.

A comparison of tables 9 and 10 indicates very similar psychometric properties, means and standard deviations in both samples for all measures, except peer-reported Psychoticism, for which internal consistencies varied about .05 (.68/.66 vs. .74/.61). However, since peer-reports were more reliable for one and less reliable for the other peer in the core sample compared with the total sample, and both peer scores will be aggregated later on, these differences will be averaged out. Overall, these comparisons

underpin optimism that later analyses using different subsamples will be based on comparably reliable data.

Table 9
Psychometric Properties of Predictor Variables: Total Sample

Scale	N	No. of items	Cronbach's α	r_{ii}	No. of items with corrected r_{it} < .20	Item number	M	SD
NEO-PI-R								
Self								
N	844	48	.93	.22	3	21, 141, 226	84.23	23.56
E	844	48	.89	.15	5	22, 112, 157, 167, 197	109.57	19.28
O	844	48	.87	.13	8	58, 88, 143, 148, 153, 208, 218, 238	116.31	17.55
A	844	48	.85	.11	5	29, 54, 129, 194, 219	119.19	15.45
C	844	48	.89	.16	6	10, 35, 105, 140, 150, 240	123.43	17.56
Peer 1								
N	839	48	.93	.21	5	21, 81, 111, 141, 226	79.53	22.14
E	839	48	.89	.15	4	22, 112, 167, 212,	111.91	18.96
O	839	48	.87	.12	10	58, 78, 88, 143, 148, 153, 183, 208, 218, 238	108.76	16.84
A	839	48	.88	.14	7	29, 54, 84, 129, 194, 219, 239	118.74	17.42
C	839	48	.92	.21	2	150, 240	129.81	19.75
Peer 2								
N	839	48	.93	.22	3	21, 141, 226	81.08	21.89
E	839	48	.89	.15	4	22, 112, 167, 212	112.04	18.29
O	839	48	.86	.11	10	58, 78, 88, 143, 148, 153, 183, 198, 208, 238	110.18	15.93
A	839	48	.89	.15	5	84, 129, 194, 219, 239	118.88	17.67
C	839	48	.92	.20	0	-	129.47	19.11
EPQ-RK								
Self								
P	1760	14	.59	.09	6	6, 26, 31, 37, 47, 50	2.44	1.84
Peer 1								
P	1762	14	.68	.13	3	6, 31, 47	2.49	2.22
Peer 2								
P	1753	14	.66	.12	5	6, 26, 31, 37, 47	2.45	2.16
LPS-K	590	7 x 40	-	-	-	-	184.26	31.12
RAPM-20	578	36	-	-	-	-	16.47	5.88

Note: r_{ii} = mean inter-item correlation, r_{it} = item-total correlation.

Table 10
Psychometric Properties of Predictor Variables: Subsample with Complete Data

Scale	No. of items	Cronbach's α	r_{ii}	No. of items with corrected $r_{it} < .20$	Item number	M	SD
NEO-PI-R							
Self							
N	48	.93	.22	4	21, 126, 141, 226	83.70	23.52
E	48	.89	.16	6	22, 52, 112, 157, 167, 197	111.77	19.20
O	48	.88	.14	7	58, 88, 143, 148, 208, 218, 236	118.60	18.11
A	48	.87	.12	8	29, 54, 84, 164, 194, 219, 239, 144	118.30	16.13
C	48	.90	.17	5	35, 20, 105, 140, 150	122.24	18.34
Peer 1							
N	48	.93	.21	5	21, 81, 111, 141, 226	81.46	22.81
E	48	.88	.14	7	2, 22, 42, 112, 157, 167, 212	111.54	18.48
O	48	.86	.11	11	58, 78, 88, 138, 143, 148, 153, 198, 208, 228, 238	109.17	16.39
A	48	.88	.13	7	29, 84, 89, 129, 194, 219, 239,	117.84	17.24
C	48	.92	.21	3	140, 150, 240	129.09	20.05
Peer 2							
N	48	.93	.22	3	21, 141, 226	82.23	22.28
E	48	.89	.14	6	22, 67, 112, 132, 197, 212	112.28	18.24
O	48	.84	.10	15	28, 58, 78, 83, 88, 113, 153, 183, 193, 198, 118, 143, 148, 208, 238	111.13	15.27
A	48	.90	.16	5	84, 129, 194, 219, 239	118.32	18.05
C	48	.92	.20	1	20	128.61	19.18
EPQ-RK							
Self							
P	14	.58	.10	6	3, 6, 16, 26, 31, 39	2.67	1.85
Peer 1							
P	14	.74	.17	0	-	2.57	2.41
Peer 2							
P	14	.61	.10	6	6, 26, 31, 37, 44, 47	2.62	2.05
LPS-K	7 x 40	-	-	-	-	184.90	30.78
RAPM-20	36	-	-	-	-	17.01	5.93

Note: N = 267, r_{ii} = mean inter-item correlation, r_{it} = item-total correlation.

A well-known problem of the Psychoticism scale is its difficulty and the resulting positive skew of the score distribution. While its revision (Eysenck, Eysenck & Barrett, 1985; Ruch, 1999) tackled this problem, it is not unlikely that it will still appear in the revised version. Indeed, inspections of histograms and highly significant Kolmogorov-Smirnov-z-tests (all $p < .001$) indicated that this was true in the present study for self- as well as both peer-reports. Taking the square root of the raw scores (increased by 1) was an adequate transformation to correct the skewness. All subsequent analyses were based on these transformed P scores. The other personality, intelligence and creativity measures were inconspicuous with respect to deviation from normal distribution.

3.2.2 Aggregation of measures

The left side of table 11 depicts the agreement of the two peers on personality measures for the total sample. Pearson product-moment as well as intraclass correlations were all between .40 (C and P) and .51 (E). These values indicate rather high consensus (Funder, 1987). Both peer-reports were therefore aggregated for each scale. The left side of the table reveals even higher accuracy (i.e., self-other agreement) of personality judgments, lowest for A (r = .47, ICC 1, 2 = .47) and P (r = .50, ICC 1, 2 = .44) and highest for E (r = .61, ICC 1, 2 = .60). In order to receive maximally pure estimates of true personality dimensions, self- and mean peer-reports were also averaged to one highly aggregated score per dimension.

Table 11
Correlations and Reliabilities of Personality Reports: Peer X Peer and Self X Mean Peer

	Peer 1 X peer 2		**Self X mean peer**	
	r	**ICC 1, 2**	**r**	**ICC 1, 2**
NEO-PI-R (N = 837-840)				
N	.44**	.44	.54**	.52
E	.51**	.51	.61**	.60
O	.45**	.45	.53**	.52
A	.46**	.46	.47**	.47
C	.40**	.40	.53**	.52
EPQ-RK (N = 1746-1751)				
P	.40**	.40	.50**	.44

Note: * p < .05, ** p < .01 (both two-tailed).

Self ratings on 'creative' and 'uncreative – creative' adjective scales correlated .67 in the total sample (p < .01, N = 1759) and were averaged after z-standardization. Consensus of peers on the BIPOL adjective 'uncreative – creative' was reasonably high for a single item (r = .31, p < .01, ICC 1, 2 = .31, N = 1738) and thus satisfactory for aggregation. The aggregate of the 60 'creative – uncreative' video ratings from GOSAT was recoded for subsequent analyses, with high values now indicating high creativity ratings.

So far, theses aggregation steps leave us with five indicators of a disposition towards creativity: aggregated originality and elaboration ratings from the T-88, and mean self, peer and video-based stranger ratings. Table 12 lists the intercorrelations of these five indicators, below diagonal for the total sample and above diagonal for those cases with complete data on all indicators, yielding an N slightly higher than that of the core

sample. Differences between corresponding coefficients of both samples were small. Correlations were highest for both T-88 scores (.61/.55) and between self- and mean peer-reports on the adjective scales (.47/.45).

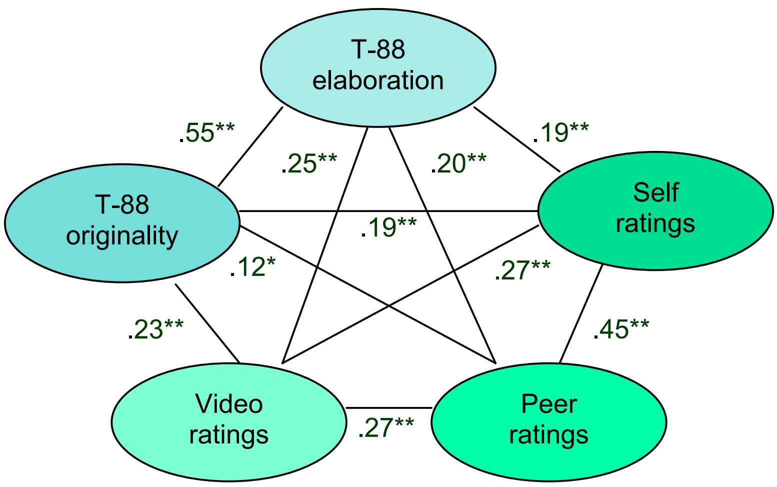
Table 12
Aggregated Creativity Indicators Intercorrelations

	T-88 elaboration	T-88 originality	Mean self 'creative'	Mean peer 'creative'	Mean video 'creative'
T-88 elaboration	-	.55**	.19**	.20**	.25**
T-88 originality	.61** (828)	-	.19**	.12*	.23**
Mean self 'creative'	.20** (806)	.18** (806)	-	.45**	.27**
Mean peer 'creative'	.24** (799)	.16** (799)	.47** (1732)	-	.27**
Mean video 'creative'	.24** (294)	.24** (294)	.25** (523)	.23** (523)	-

Note: * p < .05, ** p < .01, (both two-tailed).
Below diagonal: Missing cases pairwise excluded, N in braces.
Above diagonal: Missing cases listwise excluded, N = 287.

A striking feature of this table is that all these various measures of a creative disposition correlate positively and significantly (i.e., the matrix exhibits a positive manifold sensu Spearman, 1904), indicating noteworthy nomological validity. It illustrated in a nomological network (figure 2), using core sample results from above the diagonal of table 12.

Figure 2
Nomological Network of Aggregated Creativity Indicators



Note: * p < .05, ** p < .01 (both two-tailed), missing cases listwise excluded, N = 287.

For further investigation of creativity structure, the five indicators were entered into an exploratory principal component factor analysis. Data adequacy was already suggested by the correlation matrix and confirmed by a highly significant Bartlett test of sphericity ($p < .01$) and an acceptable measure of sample adequacy (MSA $\geq .5$; Kaiser-Meyer-Olkin criterion). Initial eigenvalues were 2.08, 1.16, .75, .58, and .43. A parallel analysis of 100 random correlation matrices with identical frame conditions yielded eigenvalues of 1.20, 1.10, 1.03, .97 and .90, which converged with Kaiser and scree test criteria in suggesting a two factor solution. Since table 12 indicated a meaningful interrelation between all variables, direct oblimin rotation was applied, with a delta of .119 derived from iterative hyperplane counts (based on factor pattern matrices). The final two factor solution explained 64.72% of the variance, with the correlation of the two factors being .31. Table 13 reports the final factor structure matrix. As can be seen, the first factor was marked by high loadings of the self and peer ratings (both .81), as well as by a substantial loading of the video ratings (.59). Loadings on the second factor were highest for the two T-88 scores (.87 and .88). The video ratings showed also a substantial secondary loading of .40 on this factor. Communalities indicate that the video ratings were least well represented by the two factors.

Table 13
Factor Structure Matrix of the Aggregated Indicators after Oblimin Rotation

	1.	**2.**	**h^2**
T-88 elaboration	.28	.87	**.75**
T-88 originality	.22	.88	**.77**
Mean self ‘creative’	.81	.20	**.65**
Mean peer ‘creative’	.81	.16	**.67**
Mean video ‘creative’	.59	.40	**.40**
Eigenvalues after rotation / Explained variance	**1.78**	**1.74**	**64.72 %**

Note: N = 287

The two oblique factors were re-entered into a principal component factor analysis to receive a hierarchical creativity factor structure with a higher-order general factor on top (Bartlett test and MSA were again acceptable). The upper half of table 14 reports factor loadings of the two oblique factors on and their communalities with this higher-order factor, which explained 65.33% of their variance. In the lower half of the table, values for the first unrotated principal component of the five creativity indicators are given. This general factor explained 45.55% of their variance, was nearly equally well represented by all five variables (with loadings ranging between .61 and .70) and was perfectly (1.00) correlated with the higher-order general factor.

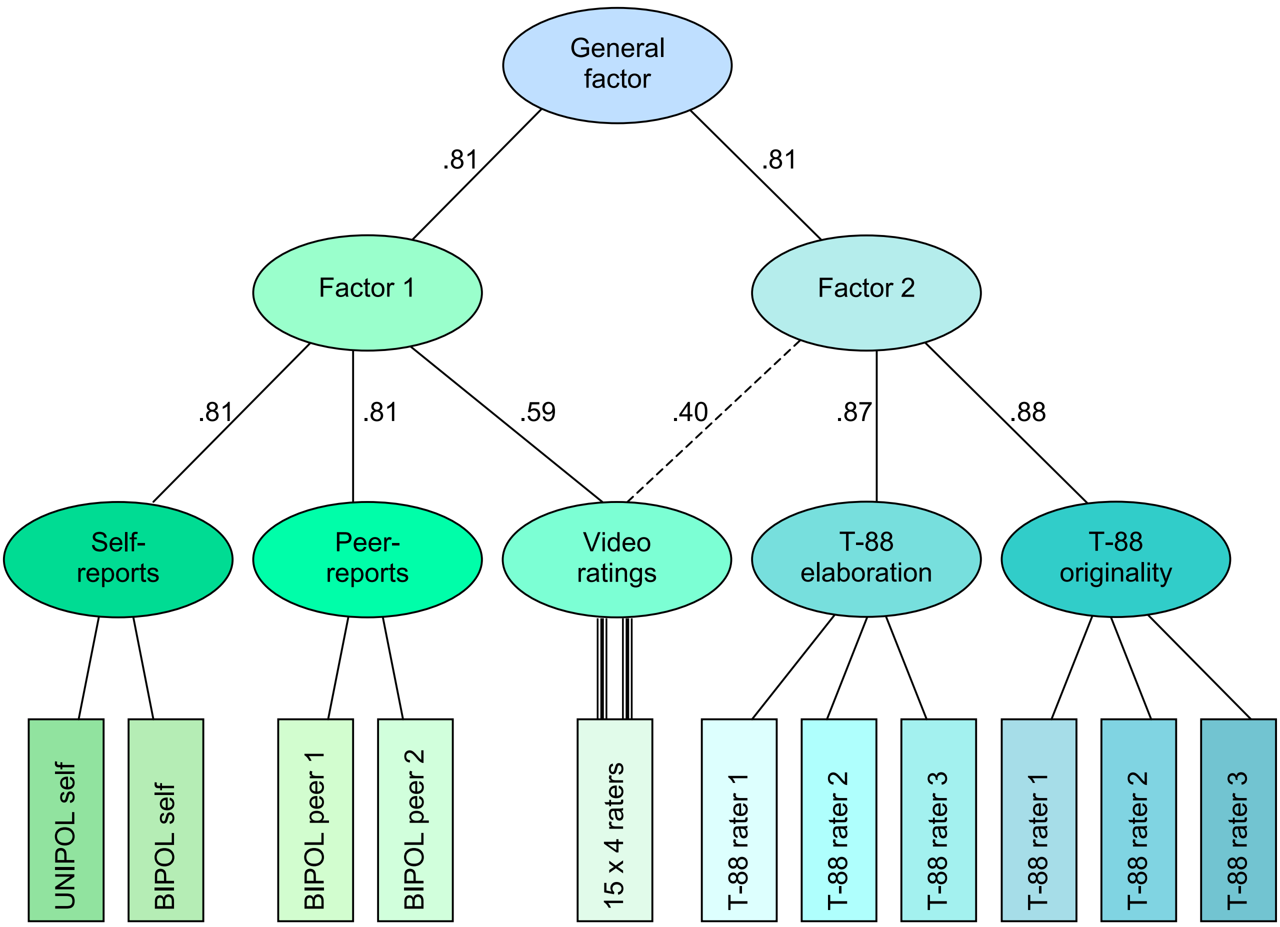
Table 14
Higher-order Factor of the Aggregated Indicators

	1.	h²
Factor 1	.81	**.65**
Factor 2	.81	**.65**
Explained variance (%)	**65.33**	**65.33**
T-88 elaboration	.70	**.49**
T-88 originality	.67	**.44**
Mean self 'creative'	.63	**.40**
Mean peer 'creative'	.61	**.38**
Mean video 'creative'	.61	**.38**
Explained variance (%)	**41.55**	**41.55**

Note: N = 287

Figure 3 summarizes the aggregation of indicators (lower part) and factor structure of the disposition towards creativity (upper part) in this study.

Figure 3
Indicators and factor structure of the disposition towards creativity



Note: Factor loadings below .40 were omitted.

3.2.3 Age and sex effects

Before the relation between the indicators and factors of a creative disposition and other psychometric measures were explored, their dependence on subjects' age and sex had to be controlled. This was important since (a) developmental and sex difference questions were out of scope of this study, so age and sex effects could bias conclusions about general relations between variables in adult age, and (b) uncorrected age and sex effects inflate twin correlations, therefore biasing estimates of genetic and environmental influences on variables in behavior genetic analyses (McGue & Bouchard, 1984). Age and sex effects on creativity indicators and factors are shown in table 15. Positive correlations with sex indicate higher values for women. Video ratings were omitted in this table, since the aggregate taken from Borkenau and colleagues (2001) was already corrected for age and sex effects. Biserial correlations of the others with sex and Pearson correlations with age were generally very low (ranging between ±.14). Only peer ratings were significantly higher for women. Both T-88 scores and the second creativity factor were significantly higher for younger subjects, while self ratings were significantly higher for older subjects.

Table 15
Correlations of Creativity Indicators with Sex and Age

	T-88 elaboration	T-88 originality	Mean self 'creative'	Mean peer 'creative'	Creativity factor 1	Creativity factor 2	Creativity g-factor
Sex	.03	.00	.00	.14**	-.03	-.06	-.06
	(828)	(828)	(1759)	(1738)	(287)	(287)	(287)
Age	-.14**	-.07*	.10**	.05	-.02	-.14*	-.10
	(790)	(790)	(1074)	(1064)	(287)	(287)	(287)

Note: * p < .05, ** p < .01 (both two-tailed), N in braces.
Males were coded as 1, females as 2.

Table 16 shows the same correlations for personality (aggregated over self- and mean peer-reports) and intelligence measures. Age and sex effects were a bit stronger (between -.23 and .24 for sex and between -.46 and .20 for age) and more common here. In this sample, men were more emotionally stable, less agreeable, more conscientious, more psychotic and more intelligent than women, and younger subjects were more neurotic, extraverted and open to experience, less agreeable and conscientious, more psychotic, and had a remarkably higher general and fluid, but slightly lower crystallized intelligence. All these effects resemble those normally reported in the literature in size and direction (e. g. Angleitner & Ostendorf, 2003; Ruch, 1999; Horn & Cattell, 1967).

Table 16
Correlations of Personality and Intelligence Measures with Sex and Age

	NEO-PI-R N	NEO-PI-R E	NEO-PI-R O	NEO-PI-R A	NEO-PI-R C	EPQ-RK P	g	g_f	g_c
Sex	.24**	.01	.06	.16**	-.10**	-.08**	-.23**	-.21**	-.16**
	(840)	(840)	(840)	(840)	(840)	(1746)	(568)	(590)	(590)
Age	-.24**	-.09*	-.13**	.20**	.15**	-.29**	-.37**	-.46**	.09*
	(801)	(801)	(801)	(801)	(801)	(1069)	(568)	(590)	(590)

Note: * p < .05, ** p < .01 (both two-tailed), N in braces.
Males were coded as 1, females as 2.
All personality measures were aggregated over self- and two peer reports.

Subjects' age and sex were regressed on all variables (including non-aggregated personality self- and mean peer-reports, which were omitted here), and all subsequent phenotypic and behavior genetic analyses were solely based on residual scores corrected for sex and age effects.

3.2.4 Phenotypic relations of creativity with intelligence and personality

3.2.4.1 Relations of creativity with intelligence

First, relations between creativity indicators and general, fluid and crystallized intelligence were explored. Correlations of these variables are listed in table 17. A first inspection reveals that all but one correlation, which was close to zero (-.01), were positive. However, none was greater than .35. Interpreting false-positive results stemming from multiple testing will be avoided by considering only results significant on one percent α level. To test whether the g_f and g_c differ significantly in their relation to creativity variables, two-tailed difference t-tests were conducted (Diehl & Staufenbiel, 2001, p. 693; see Bortz, 1999, formula 6.97, for a similar z-test). The row in the middle of table 17 gives significance levels for these tests.

While all correlations between T-88 elaboration and intelligence factors were highly significant and of similar magnitude, only crystallized intelligence exhibited a strong association with originality, which was significantly higher than that of g_f. No intelligence factor correlation with self- or peer-reported creativity was highly significant. On the other hand, the GOSAT video ratings showed the strongest relation of all creativity indicators with all intelligence factors to a similar extend. Only the grossly overlapping

Table 17
Correlations of Creativity with Intelligence

	T-88 elaboration	T-88 originality	Mean self 'creative'	Mean peer 'creative'	Mean video 'creative'	Creativity factor 1	Creativity factor 2	Creativity g-factor
g	.19** (286)	.07 (286)	.03 (511)	.09 (511)	.35** (555)	.23** (270)	.20** (270)	.28** (270)
g_f	.20** (300)	.02 (300)	.07 (532)	.11* (532)	.29** (574)	.27** (282)	.16** (282)	.29** (282)
g_c	.22** (300)	.22** (300)	-.01 (532)	.02 (532)	.32** (574)	.07 (282)	.30** (282)	.21** (282)
Difference test (g_f-g_c)	n. s.	**	n. s.	*	n. s.	**	*	n. s.
$g_f.g_c$	.10 (297)	-.12* (297)	.09* (529)	.12** (529)	.16** (571)	.28** (279)	.01 (279)	.18** (279)
$g_c.g_f$	.14* (297)	.25** (297)	-.05 (529)	-.05 (529)	.20** (571)	-.09 (279)	.25** (279)	.10 (279)

Note: * p < .05, ** p < .01, n. s.: non-significant (all two-tailed), N in braces.

fluid and general intelligence correlated significantly with the first creativity factor, the difference between g_f and g_c relations being highly significant in favor of g_f. All three intelligence factors, but especially g_c (.30, difference to the .16 relation of g_f significant on the five percent α level), correlated with the second factor. Finally, all three intelligence factors were significantly correlated with the creativity general factor (general and fluid intelligence slightly, but insignificantly higher than crystallized).

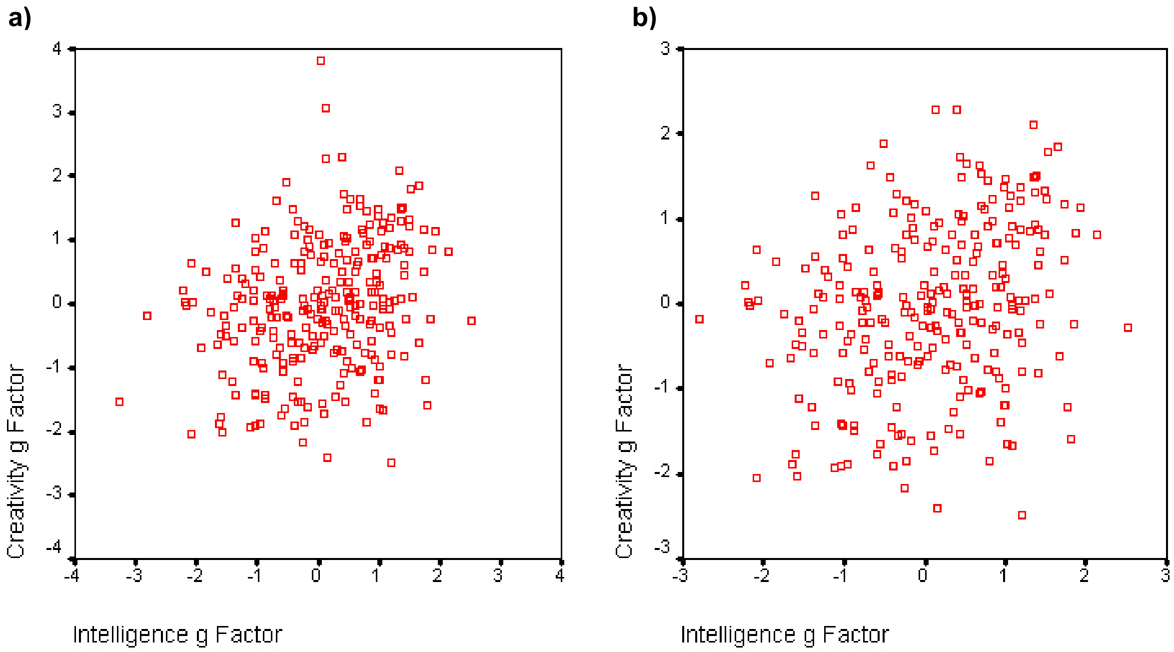
To further test whether the g_f or the g_c facet of intelligence was a more important predictor of a disposition towards creativity, partial correlations were calculated, with one facet controlled in correlations of the other facet with creativity variables (last two rows of table 17). It has to be noted that g_f and g_c were strongly overlapping ($r = .52$, $p < .01$, N = 590), with a meaningful core of general intelligence. These partial correlations therefore removed valid variance from both variables. They are informative, however, in that they indicate the relative importance of *genuine* fluid and crystallized intelligence aspects.

Partialling out the other facet decreased the correlations of both g_f and g_c with T-88 elaboration score, but slightly increased the advantage of g_c. The pure aspects of g_f and g_c seem to have antagonistic effects on originality, with controlling the other facet yielding a significantly negative relationship with g_f (-.12) and a slightly increased one with g_c. A similar effect in the opposite direction, but of neglectable magnitude, can be suspected in the pattern observable in both correlations with self- and peer-reported creativity. The correlations with the video ratings, in contrast, were similarly decreased

for g_f and g_c residuals, with both staying highly significant. All three aspects, genuine fluid and crystallized intelligence as well as their common core, seem to be influential here. The relations with creativity factor scores reflected what was already observable on aggregated measures level: Only genuine g_f correlated with factor 1 and only genuine g_c correlated with factor 2. Controlling the other facet had reductive effects on relations with the general creativity factor for both. But while the non-significant difference between the correlations of g_f and g_c with this factor stayed the same, only the one with the g_f residual remained significantly different from zero.

Guilford's threshold hypothesis was tested using the two methods he suggested (Guilford, 1967a, b, 1981). First, general intelligence was plotted against the creativity g factor (figure 4a). While this scatter plot might remind one of the triangular pattern Guilford hypothesized, it has to be remarked that 3 of the 270 data points depicted here lie outside 3 standard deviations (two > 3 SD on the creativity g factor, one < 3 SD on intelligence g). When these three outliers were removed (figure 4b), the triangular pattern diminished completely.

Figure 4
Scatter Plots of Intelligence and Creativity g Factors



Guilford's second suggested test of the threshold hypothesis demands correlating creativity and intelligence measures in a high-IQ-sample. It hypothesizes a non-significant correlation for such a sample. To avoid false interpretations of such a decrease in correlations as a confirmation of the threshold hypothesis when it was just

based on range restriction, two extreme groups were build: The first contained all subjects with general intelligence factor values at least one standard deviation above sample mean (N = 44), while the second contained all subjects at least one standard deviation below mean (N = 44). Neubauer and colleagues (2000) calculated an IQ mean of 111 for this sample's LPS-K results. Since the LPS norms stem from 1962, Neubauer and colleagues argued for an effective IQ mean of around 100 in this sample, based on the Flynn effect (describing an increase of mean population IQ of about 3 points per decade). IQ of the high-g extreme group subjects should therefore be at least around 115, qualifying for a test of Guilford's hypothesis.

Results for the high-g group indeed indicated a non-significant correlation of general intelligence with the first and second creativity factor as well as with the higher-order general factor (.10, -.09, and -.04, respectively, all n. s. in two-tailed tests). However, results were similar for the low-g group (.06, .08, and .09, respectively, all n. s. in two-tailed tests), even though all results were in positive direction here.

3.4.2.2 Relations of creativity with personality

Correlation analyses to clarify the relation of dispositional creativity and personality were separately conducted for personality self-reports, mean peer-reports, and aggregated self- and mean peer-reports, yielding a total of 144 correlation coefficients (first 8 columns of table 18). Since danger of false-positive significant correlations was especially high here, only correlations that were significant on one percent α level and meaningfully replicable within this dataset will be interpreted. Openness to Experiences easily passed these criteria: All 24 correlations between O and creativity indicators and factors were highly significant, even reaching .52 on highest level of aggregation. Second, 18 of 24 correlations between Extraversion and creativity indicators reached significance on one percent α level, with the non-significant ones being exclusively all those with T-88 scores. Interestingly, E was also significantly associated with the second creativity factor, on which both T-88 dimensions showed high loadings.

Openness and Extraversion were the only two personality dimensions which showed noteworthy relations to the highest-level creativity aggregate, the creativity general factor. In contrast, Neuroticism was only significantly related (in negative direction) with creativity self- and peer-reports. But while all six correlations were significant, they were

Table 18
Correlations of Creativity with Personality

	T-88 elaboration	T-88 originality	Mean self 'creative'	Mean peer 'creative'	Mean video 'creative'	Creativity factor 1	Creativity factor 2	Creativity g-factor
Self-report								
NEO-PI-R	(N = 789)	(N = 789)	(N = 789)	(N = 781)	(N = 300)	(N = 286)	(N = 286)	(N = 286)
N	.03	.04	-.13**	-.09*	-.01	-.04	.13*	.06
E	-.01	.05	.25**	.17**	.26**	.33**	.17**	.31**
O	.19**	.26**	.35**	.26**	.34**	.42**	.32**	.46**
A	-.07*	-.11**	.02	.05	.13*	.00	-.09	-.05
C	-.05	-.05	.09**	.02	-.10	.02	-.21**	-.12*
EPQ-RK	(N = 776)	(N = 776)	(N = 1073)	(N = 1063)	(N = 525)	(N = 287)	(N = 287)	(N = 287)
P	.02	.05	.00	.04	.11*	.00	.05	.03
Mean peer-report								
NEO-PI-R	(N = 785)	(N = 785)	(N = 786)	(N = 778)	(N = 299)	(N = 285)	(N = 285)	(N = 285)
N	-.04	.00	-.07*	-.12**	-.03	-.02	.03	.00
E	.03	.04	.16**	.17**	.19**	.25**	.16**	.26**
O	.23**	.23**	.22**	.27**	.40**	.38**	.31**	.43**
A	.03	.02	.02	.10**	.11	.05	-.02	.02
C	-.03	-.05	.01	.04	.02	.00	-.14*	-.08
EPQ-RK	(N = 774)	(N = 774)	(N = 1067)	(N = 1060)	(N = 524)	(N = 286)	(N = 286)	(N = 286)
P	.09**	.04	.04	.02	.07	-.05	.08	.01
Aggregate								
NEO-PI-R	(N = 785)	(N = 785)	(N = 786)	(N = 778)	(N = 299)	(N = 285)	(N = 285)	(N = 285)
N	.01	.03	-.12**	-.12**	-.02	-.04	.10	.04
E	.01	.05	.23**	.19**	.25**	.33**	.18**	.32**
O	.24**	.28**	.33**	.31**	.42**	.47**	.37**	.52**
A	-.02	-.06	.02	.09*	.14*	.03	-.07	-.03
C	-.05	-.06	.06	.04	-.05	.01	-.20**	-.11
EPQ-RK	(N = 773)	(N = 773)	(N = 1066)	(N = 1059)	(N = 524)	(N = 286)	(N = 286)	(N = 286)
P	.06	.06	.02	.03	.10*	-.04	.07	.02

Note: * p .05, ** p < .01 (all two-tailed), N in braces.

low and two only reached the five percent α level. Additionally, the association with N was not found for the first creativity factor, which was highly loaded by the self- and peer ratings. Conscientiousness showed only one spurious and not replicated correlation with creativity indicators, but surprisingly consistent and quite substantial negative correlations (up to -.21, one only significant on five percent α level) with the second creativity factor. Agreeableness and Psychoticism showed only few and not replicable significant correlations with creativity indicators, and none of those was meaningful enough to reappear on factor level.

3.4.2.3 Regression analyses

Next, relations between variables were closer examined by several stepwise regression analyses of all personality dimensions (on highest aggregation level) and fluid and crystallized intelligence on the three creativity factors. General intelligence was excluded, because it was highly correlated with both fluid (.92) and crystallized intelligence (.77), which promised a more differentiated picture. F-test p levels were .05 for inclusion and .10 for exclusion of variables in all analyses. In none of the three regressions did visually inspected scatter plots of standardized predicted values by standardized residuals indicate signs of non-linearity or heteroskedasticity, nor did any Durbin-Watson test of autocorrelation reach significance (d = 1.87, 1.85, and 1.94, for factor 1, 2 and the general factor regressions, respectively, all n. s.; Backhaus, Erichson, Plinke & Weiber, 2000).

The first stepwise regression analysis of personality and intelligence scores on creativity factor 1 yielded an explanation of 28% variance by Openness to Experience, Extraversion, and fluid and crystallized intelligence (table 19). O alone explained 21%. The entering of g_c in the fourth step had an interesting effect: While showing a positive (but insignificant) zero-order correlation with the first creativity factor, g_c had a significantly negative beta weight in this multiple regression. On the other hand, the introduction of g_c increased the beta weights of O (with $r_{gc, O} = .28$, $p < .01$, N = 305) and especially g_f, tentatively indicating a suppression effect of g_c. This replicates the antagonistic effect of g_f and g_c in predicting self- and peer-reported creativity, which were the marker variables of factor 1. It is noteworthy, though expectable, that the

entering of g_c in the regression had an reductive effect on the tolerances (from all greater .81 to greater .66).

Table 19
Stepwise Regression of Personality and Intelligence on Creativity Factor 1

	Predictors	Beta weights	R^2 change	Total adjusted R^2
Step 1	**O**	.46***	.21***	.21***
Step 2	**O**	.43***		
	g_f	.17**	.03**	.24***
Step 3	**O**	.35***		
	g_f	.19***		
	E	.19***	.03**	.26***
Step 4	**O**	.39***		
	g_f	.27***		
	E	.16**		
	g_c	-.17**	.02**	.28***

Note: Predictors: N, E, O, A, C, P, g_f, & g_c.
All personality predictors were aggregated over self- and two peer-reports.
* $p < .05$, ** $p < .01$, *** $p < .001$, N = 279.

The second creativity factor was best predicted by Openness to Experience, crystallized intelligence, Conscientiousness (-), and Extraversion (table 20). These predictors explained only 21% of its variance, though. O alone explained 14%. C, which added about 3% incremental predictive validity, did not reach significance in the zero-order correlations reported above (but showed a similar negative trend). The entrance of E in step 4 reduced tolerances (from all greater .90 to greater .70), supposingly because of its overlap with O ($r_{E, O} = .39$, $p < .01$, N = 801).

Table 20
Stepwise Regression of Personality and Intelligence on Creativity Factor 2

	Predictors	Beta weights	R^2 change	Total adjusted R^2
Step 1	**O**	.37***	.14***	.13***
Step 2	**O**	.30***		
	g_c	.21***	.04***	.17***
Step 3	**O**	.29***		
	g_c	.21***		
	C	-.16**	.03**	.19***
Step 4	**O**	.22**		
	g_c	.23***		
	C	-.19**		
	E	.14*	.02*	.21***

Note: Predictors: N, E, O, A, C, P, g_f, & g_c.
All personality predictors were aggregated over self- and two peer-reports.
* $p < .05$, ** $p < .01$, *** $p < .001$, N = 279

The variance of the general creativity factor was predictable to 30% by Openness to Experience, fluid intelligence, and Extraversion (table 21). O alone explained 26%. Again, predictors were somewhat interrelated, but all tolerances were still greater than .78 when all three variables were entered.

Table 21
Stepwise Regression of Personality and Intelligence on the Creativity g Factor

	Predictors	Beta weights	R^2 change	Total adjusted R^2
Step 1	**O**	.51***	.26***	.26***
Step 2	**O**	.48***		
	g_f	.16**	.02**	.28***
Step 3	**O**	.42***		
	g_f	.18**		
	E	.15**	.02**	.30***

Note: Predictors: N, E, O, A, C, P, g_f, & g_c.
All personality predictors were aggregated over self- and two peer-reports.
* $p < .05$, ** $p < .01$, *** $p < .001$, N = 279

A more differentiated perspective on the relative influences of each of these partly overlapping variables on dispositional creativity would be useful, especially with respect to the g_f-g_c question and Peterson et al.'s (2002) result of a composite of E and O best predicting creativity. To get such a perspective, communality analyses were conducted for the relationships of all three creativity factors to their significant predictors from the stepwise regressions. In a communality analysis, the explained criterion variance of a multiple regression is partitioned into unique influences of the predictors and influences common to several predictors, i.e. criterion variance predicted by the overlap of several predictors (Cooley & Lohnes, 1976, pp. 218-223). Table 22 lists the results for all three factors. When multiplied with 100, values in this table can be interpreted as percentages of explained criterion variance. They add up to the determination coefficient (R^2) of the corresponding multiple regression (last row), which is not adjusted for number of predictors here, therefore slightly larger than in the tables 19 to 21.

Table 22
Communality Analyses of Creativity Factors Predictions

Creativity Factor 1		Creativity Factor 2		Creativity g Factor	
U(O):	**.115**	**U(O):**	**.038**	**U(O):**	**.139**
U(g_f):	**.054**	**U(g_c):**	**.048**	**U(g_f):**	**.030**
U(E):	.019	**U(C):**	**.035**	U(E):	.018
U(g_c):	**.022**	U(E):	.014	**C(O, g_f):**	**.040**
C(O, g_f):	.011	**C(O, g_c):**	**.041**	**C(O, E):**	**.080**
C(O, E):	**.078**	C(O, C):	.016	C(g_f, E):	-.006
C(O, g_c):	-.019	**C(O, E):**	**.042**	C(O, g_f, E):	.008
C(g_f, E):	-.001	C(g_c, C):	-.002		
C(g_f, g_c):	**-.020**	C(g_c, E):	-.008		
C(E, g_c):	.008	C(C, E):	-.008		
C(O, g_f, E):	.013	C(O, g_c, C):	.009		
C(O, g_f, g_c):	**.024**	C(O, g_c, E):	.002		
C(O, E, g_c):	-.003	C(O, C, E):	-.008		
C(g_f, E, g_c)	-.005	C(g_c, C, E)	.004		
C(O, g_f, E, g_c):	-.003	C(O, g_c, C, E):	-.005		
R^2:	**.293**	**R^2:**	**.218**	**R^2:**	**.309**

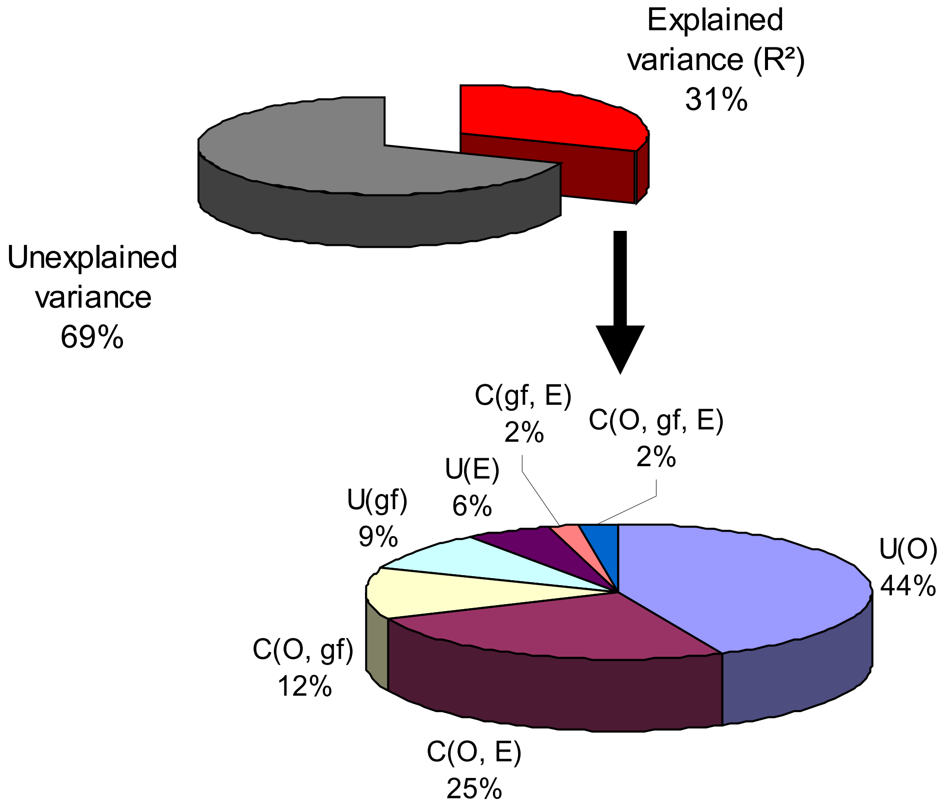
Note: U: Uniqueness, C: Communality.
N = 279.
Fractions ≥ |.020| (= 2% explained variance) are printed in bold face.

Results for creativity factor 1 are shown in the first column. More than one third of the variance explained in this factor (11.5%) was solely attributable to Openness to Experience, and it increased to about two thirds, when the variance O shared with E was added. Unique E variance, on the other hand, contributed only a very small amount to it. The uniqueness of fluid intelligence was responsible for the next bigger share (5.4%), surprisingly followed by 2.4% common variance of O, g_f and g_c plus 2.2% unique g_c variance. This positive influence of crystallized intelligence was hidden in the stepwise regression by its suppression effects on g_f and O (identifiable by negative contributions to R^2).

The communality analysis of the regression on the second creativity factor revealed that the most important unique influence on it was not O (3.8%), but g_c (4.8%). The variance shared by O and E (4.2%) was about as predictive as the unique variance of O, with the unique E variance again only contributing a very small amount (1.4%). Other noteworthy contributions came from the overlap of O and g_c (4.1%) and unique C (3.5%).

Influences on the general creativity factor (last column of table 22, also illustrated in figure 5) were rather straightforward: The single major predictor was O, uniquely contributing 13.9%, plus 8% via shared variance with E and 4% shared with g_f. Extraversion's unique contribution was again small (1.8%), while g_f added unique 3% of predicted variance.

Figure 5
Results for the Communality Analysis of the General Creativity Factor



Note: U: Uniqueness, C: Communality. N = 279.

Some authors suggested synergistic effects of personality dimensions and intelligence on creativity: Eysenck (1995a, b) and Jensen (1996) for P, Peterson et al. (2002) for O and E. A serial of additional regression analyses was conducted to test these interaction effects. Four dummy variables containing the product of g times either E, O, a composite (sum) score of E and O, or P (each aggregate of self- and mean peer-reports) were calculated. They were entered as predictors into a hierarchical (blockwise) multiple regression in the second step, after g and the corresponding personality dimension(s) had been entered as predictors in the first step. All three creativity factors were, one after the other, entered as dependent variables in each of the four regressions, yielding a total of twelve analyses. In none of these twelve cases did the interaction term contribute incrementally to the prediction, with none of the t- and F-tests being even marginally significant (all $p > .10$).

3.4.2.4 The structure of creativity after controlling for intelligence and personality

To test the necessity of broad personality dimensions and general mental abilities for a disposition towards creativity, all dimensions of the FFM, Psychoticism (all aggregated over self- and mean peer-reports), and general, fluid and crystallized intelligence were regressed on each of the five creativity indicators (T-88 elaboration and originality, self-, peer- and video-based stranger rated creativity). The five residuals were intercorrelated (table 23). Comparisons with the zero-order intercorrelations of the same variables (table 12 and figure 2, p. 41) revealed that controlling for broad personality and intelligence dimensions (as well as sex and age) affected the convergence of the creativity indicators: All correlations were reduced, with three of the ten former significant correlations now insignificant. While nine of the ten zero-order correlations were significant on one percent α level, only two of the residual correlation reached it (T-88 elaboration with T-88 originality and mean peer ratings of creativity). All values remained, however, positive.

Table 23
Intercorrelations of Creativity Indicators after Controlling for all Predictors

	T-88 elaboration	T-88 originality	Mean self ‘creative’	Mean peer ’creative’
T-88 elaboration	-	-	-	-
T-88 originality	.48**	-	-	-
Mean self ‘creative’	.11	.14*	-	-
Mean peer ‘creative’	.17**	.11	.37*	-
Mean video ’creative’	.09	.15*	.14*	.16*

Note: * $p < .05$, ** $p < .01$ (both two-tailed). N = 267 to 283.
All variables were corrected for sex, age, N, E, O, A, C, g, g_f, & g_c.

A highly significant Bartlett test ($p < .01$) and an acceptable MSA indicated this matrix as adequate for entering into a principle component factor analysis. Initial eigenvalues were 2.08, 1.16, .75, .58, .43, and a parallel analysis of 100 random matrices with identical frame conditions (mean eigenvalues: 1.17, 1.07, 1.00, .92, .84), as well as scree and Kaiser criteria, suggested the extraction of two factors, which explained 59.17%. This was 5.55% less than the two factors extracted from zero-order correlations explained (see table 13). Similar to the factor analysis of uncorrected creativity indicators, the two factors were rotated using direct oblimin rotation with a delta of .119. An iterative hyperplane count based on factor pattern matrices confirmed that this was a tenable solution. The correlation of both factors was .26, not significantly

different from the correlation of the oblique factors derived from uncorrected correlations. Table 24 shows that the first factor was again marked by high loadings of the self and peer creativity ratings, as well as a moderate loading of the video-based stranger ratings, while the second factor was marked by the two T-88 scoring dimensions. The secondary loading of the video ratings on factor two was missing in the analysis of corrected indicators. The video ratings were also not very well represented by these two factors, the communality being only .27. However, factor structure of both factors was nearly identical with that of the corresponding factor extracted from uncorrected creativity indicators (Tucker's phi was .998 for factor 1 and .986 for factor 2; Bortz, 1999, formula 15.72a), and Pearson correlations between corresponding factors were high (.83 and .88 for factors 1 and 2, respectively, both $p < .01$, $N = 267$).

Table 24
Factor Structure Matrix of the Creativity Indicators, Corrected for all Predictors, after Oblimin Rotation

	1.	**2.**	**h²**
T-88 elaboration	.21	.86	**.74**
T-88 originality	.20	.86	**.75**
Mean self 'creative'	.78	.15	**.61**
Mean peer 'creative'	.77	.17	**.59**
Mean video 'creative'	.52	.18	**.27**
Eigenvalues after rotation / Explained variance	**1.55**	**1.57**	**59.17%**

Note: N = 267. All variables were corrected for sex, age, N, E, O, A, C, g, g_f, & g_c.

The two oblique factors were again re-factorized in a principle component analysis to extract a corrected higher-order general factor (with Bartlett test being highly significant ($p < .01$) and MSA acceptable). The general factor explained 62.91% of the two oblique factors' variance (2.42% less than in the first general factor did, see table 14), with both exhibiting loadings of .79 on it (upper part of table 25). The first unrotated factor extracted from the five indicators, a general factor which was perfectly correlated with the higher-order factor, explained 35.82% of the variance (5.73% less than the corresponding uncorrected factor, see table 14). The lower part of table 25 shows the loadings of the corrected indicators, ranging between .44 for the video ratings and .68 for both T-88 elaboration and originality. This factor structure was again nearly identical with the corresponding uncorrected factor (Tucker's phi = .994), and the two correlated .82 ($p < .01$, $N = 267$).

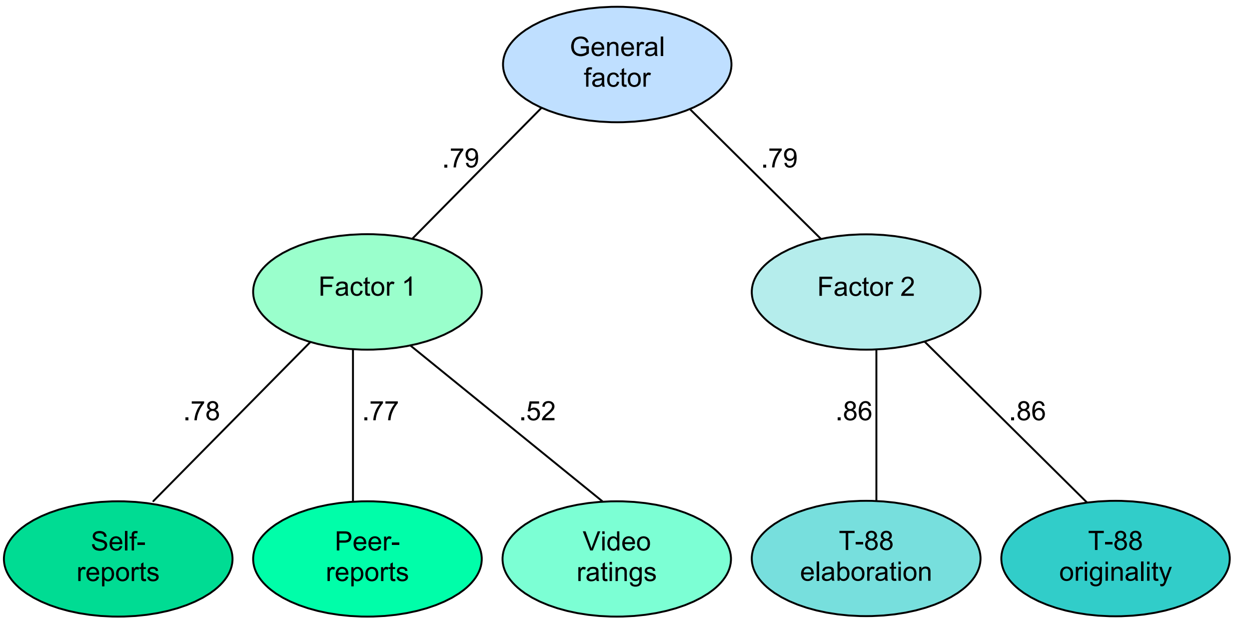
Table 25
Higher-Order Factor of the Creativity Indicators, Corrected for all Predictors

	1.	h^2
Factor 1	.79	**.63**
Factor 2	.79	**.63**
Explained variance (%)	**62.91**	**62.91**
T-88 elaboration	.68	**.46**
T-88 originality	.68	**.46**
Mean self ‘creative’	.58	**.33**
Mean peer ‘creative’	.59	**.34**
Mean video ‘creative’	.44	**.19**
Explained variance (%)	**35.82**	**35.82**

Note: N = 267. All variables were corrected for sex, age, N, E, O, A, C, g, g_f, & g_c.

Figure 6 summarizes, following figure 3, the hierarchical factor structure of the disposition towards creativity after statistical control of personality dimensions and intelligence factors.

Figure 6
Factor Structure of the Disposition towards Creativity, Corrected for all Predictors



Note: Factor loadings below .40 were omitted.

3.2.5 Genetic and environmental influences on creativity and its correlations with personality and intelligence

The etiology of dispositional creativity, i.e. the genetic and environmental influences on individual differences in it, was explored in two steps: First, within-pair intraclass correlations for MZ and DZ twins were calculated and univariate behavioral genetic structure equation models were fitted to the twin intra-pair variances and covariances in order to estimate the relative effects of genetic, shared environmental and non-shared environmental influences on creativity indicators, factors, and significant predictors. To further test the necessity of personality and intelligence for dispositional creativity, these models were also fitted to creativity indicators and factors corrected for all personality and intelligence variables assessed in this study. Second, multivariate structure equation models were fitted to twin intra-pair cross-trait cross-twin covariances (i.e. the covariance between trait 1 in twin 1 and trait 2 in twin 2 of a pair) to estimate genetic, shared environmental and non-shared environmental influences on the correlations between creativity variables and their predictors, and to estimate the amount of overlap between the sources influencing the variance of both variables.
For all subsequent analyses, all variables were corrected for effects of sex and age, and all personality dimensions were aggregates of self- and mean peer-reports. Out of the DZ twin pairs, only same-sexed pairs were included in the analyses. Behavioral genetic analyses for the personality and intelligence predictors have already been conducted with data from this sample. See Neubauer et al. (2000) for the three intelligence factors and Angleitner (2002) for the NEO-PI-R-based FFM dimensions.

3.2.5.1 Univariate behavioral genetic analyses

First hints on the etiology of individual differences in a diposition towards creativity can be deduced from a comparison of MZ and DZ twin within-pair intraclass correlations (ICC 1, 1), listed in table 26 (upper part). All ICCs were greater zero, indicating that not only environmental influences unshared by siblings contributed to the variances. However, since no ICC was perfect (or close to the reliability of the measure), all variables can still be expected to be partly influenced by the non-shared environment.

Table 26
Intraclass Correlations (ICC 1, 1) between MZ and DZ Twins

	MZ	DZ	DZ/MZ ratio
Creativity indicators and factors:			
T-88 elaboration	.46 (222)	.48 (78)	1.04
T-88 originality	.30 (222)	.32 (78)	1.07
Mean self report 'creative'	.48 (318)	.19 (161)	.40
Mean peer report 'creative'	.28 (316)	.19 (155)	.68
Mean video ratings 'creative'	.57 (158)	.38 (126)	.67
Creativity factor 1	.53 (63)	.30 (44)	.57
Creativity factor 2	.48 (63)	.44 (44)	.92
Creativity g factor	.57 (63)	.35 (44)	.61
Predictors:			
E (Self- & mean peer-reports aggregated)	.51 (223)	.29 (84)	.57
O (Self- & mean peer-reports aggregated)	.56 (223)	.25 (84)	.45
C (Self- & mean peer-reports aggregated)	.52 (223)	.20 (84)	.38
g	.80 (154)	.46 (127)	.58
g_f	.73 (164)	.41 (129)	.56
g_c	.76 (164)	.46 (129)	.61
Corrected creativity indicators and factors:			
T-88 elaboration	.39 (60)	.46 (47)	1.18
T-88 originality	.50 (60)	.38 (47)	.76
Mean self-report 'creative'	.33 (61)	.28 (49)	.85
Mean peer-report 'creative'	.12 (62)	.31 (49)	2.58
Mean video ratings 'creative'	.40 (59)	.03 (45)	.08
Creativity factor 1	.33 (53)	.25 (43)	.76
Creativity factor 2	.52 (53)	.28 (43)	.54
Creativity g factor	.53 (53)	.14 (43)	.26

Note: MZ = monozygotic, DZ = dizygotic, N in braces.
All analyses were based on values corrected for age and sex effects.
Corrected creativity indicators and factors were additionally corrected for N, E, O, A, C, g, g_f, & g_c.

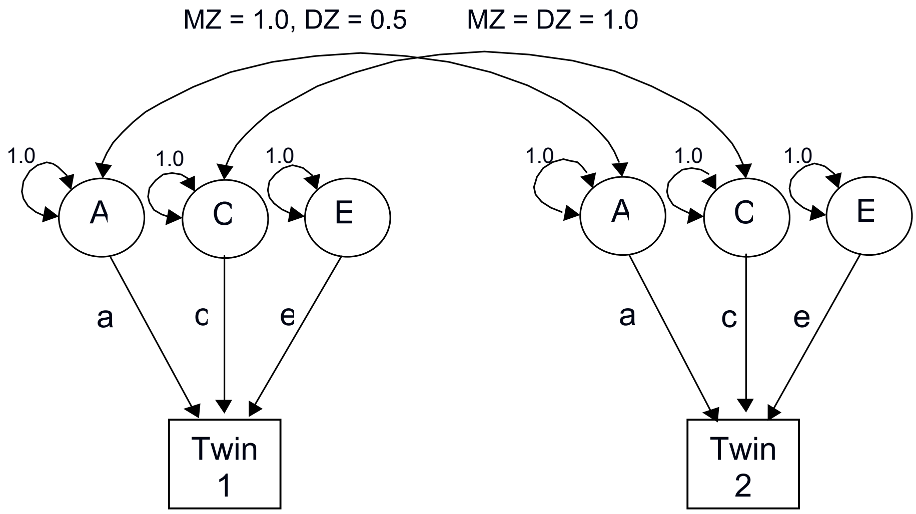
Effects of genetic differences can be concluded from higher ICCs in MZ than in DZ pairs, that is a DZ/MZ ratio below 1 (last column). This was the case for most creativity variables, except the two T-88 dimensions. DZ/MZ ratios below .5, here only true for self-reported creativity, indicated non-additive genetic effects (like dominance, epistasis and emergenesis). Since all other creativity indicators and factors had DZ/MZ ratios between .5 and 1, genetic as well as shared and non-shared environmental influences on their variance (to various degrees) can be expected.

On the same rational, twin similarities on all personality dimensions and intelligence factors indicated genetic and non-shared environmental effects acting on their variance. Comparisons of MZ-DZ resemblance for Extraversion and the three intelligence factors also suggested small shared environmental effects; those for Openness to Experience and Conscientiousness were more in line with an assumption of non-additive genetic sources of variance. Interesting results emerged for twin correlations of creativity indicators and factors corrected for all personality dimensions and intelligence factors assessed in this study: Despite the proposed necessity of some of the controlled variables for dispositional creativity (e.g. O, P or g), twin pair resemblance for the most residuals remained greater than zero, some of them even rose. The new pattern of MZ-DZ ICCs also held some surprises: While T-88 elaboration remained unaffected by genetic sources, T-88 originality suddenly showed substantial heritability. The contrary effect was observable for self- and peer-reported creativity as well as creativity factor 1, whose heritability decreased markedly. It even disappeared completely in peer-reports. The heritability of creativity factor 2, but especially of the video-based stranger ratings and the creativity general factor, on the other hand, showed a substantial increase. For the latter two, this led to an ICC pattern suggestive of non-additive genetic effects. According to Lykken (1982), at least the DZ/MZ ratio of the video ratings could be interpreted as indicative of emergenesis.

For a more precise estimate of genetic and environmental influences on individual differences in these variables, univariate structure equation models were fitted to the data, using Mx (version 1.3.51; Neale, Boker, Xie & Maes, 2002). The model specified is depicted in figure 7. Genetic (A), shared environmental (C) and non-shared environmental (E) effects on the variance of each variable were modeled as latent constructs, with As being correlated 1.0 for MZ and .5 for DZ twin pairs, while Cs were set as perfectly correlated and Es as uncorrelated. Squared estimates of the path coefficients from these constructs on the observed variables (a^2, c^2 and e^2) can be

interpreted as relative influences of the corresponding latent construct on the variance of the observed variable in percent.

Figure 7
Univariate Genetic ACE Model



For some variables (self-reported creativity, O, C, and both video-based creativity ratings and the creativity general factor after controlling for all predictors), ICCs were more indicative of non-additive genetic instead of shared environmental influences. Since an ACE model as that in figure 7 would have been inappropriate in these cases, an ADE model was fitted instead, with a latent D construct for dominance effects in exchange for C. Genetic dominance effects (i.e. intra-loci interactions of alleles) are completely shared by MZ twin siblings, while DZ twins share them to 25%. The corresponding path was fixed accordingly (i.e. 1.0 for MZ and .25 for DZ).

Table 27 and 28 show the fit indices for ACE and ADE models and their nested submodels, respectively. For most variables, highly insignificant p values for the chi-squared tests and negative AIC fit indices (Aikake's Information Criterion; χ^2 - 2df) indicate that the assigned full model had a good fit to the data. Exceptions were T-88 originality, where the ACE model deviated significantly from the data, aggregated Extraversion, where the AIC was positive and the chi-squared test approached significance (p = .08), and aggregated Conscientiousness, where the ADE model deviated significantly.

Table 27
Fit of Univariate ACE Models to Creativity Indicators, Factors, and Predictors

	N (pairs)		ACE			AE				CE				E			
	MZ	**DZ**	χ^2	**p (df = 3)**	**AIC**	χ^2	**p (df = 3)**	**LRT**	**p (df = 3)**	χ^2	**p (df = 4)**	**LRT**	**p (df = 1)**	χ^2	**p (df = 5)**	**LRT**	**p (df = 2)**
Creativity indicators:																	
T-88 elaboration	222	78	2.94	.40	-3.06	8.70	.07	5.76	.02*	**2.94**	**.57**	**.00**	**.99**	75.83	.00**	72.89	.00**
T-88 originality	222	78	11.01	.01*	5.01	11.97	.02*	.96	.33	**11.60**	**.02***	**.60**	**.44**	41.65	.00**	30.65	.00**
Peer-report 'creative'	316	155	1.78	.62	-4.22	**1.91**	**.75**	**.13**	**.72**	3.57	.47	1.79	.18	32.34	.00**	30.56	.00**
Video rating 'creative'	158	126	3.06	.38	-2.94	**4.47**	**.35**	**1.41**	**.24**	8.21	.08	5.15	.02*	83.35	.00**	80.29	.00**
Creativity factor 1	63	44	2.77	.43	-3.23	**2.77**	**.60**	**.00**	**.99**	6.43	.17	3.66	.06	28.61	.00**	25.84	.00**
Creativity factor 2	63	44	1.93	.59	-4.08	3.20	.53	1.28	.26	**2.53**	**.64**	**.61**	**.44**	26.77	.00**	24.84	.00**
Creativity g factor	63	44	3.31	.35	-2.69	**3.32**	**.51**	**.01**	**.94**	8.12	.09	4.81	.03*	34.23	.00**	30.92	.00**
Predictors:																	
E (aggregated)	223	84	6.77	.08	.77	**6.77**	**.15**	**.00**	**#**	17.20	.00**	10.43	.00**	81.07	.00**	74.30	.00**
g	154	127	.82	.84	-5.18	**1.58**	**.81**	**.76**	**.38**	37.37	.00**	36.54	.00**	190.19	.00**	189.36	.00**
g_f	164	129	4.58	.21	-1.42	**5.33**	**.26**	**.75**	**.39**	24.27	.00**	19.69	.00**	153.43	.00**	148.86	.00**
g_c	164	129	4.47	.22	-1.53	**5.85**	**.21**	**1.38**	**.24**	28.35	.00**	23.87	.00**	172.99	.00**	168.51	.00**
Indicators corrected for all predictors:																	
T-88 elaboration	60	47	3.27	.35	-2.73	5.48	.24	2.22	.14	**3.33**	**.51**	**.06**	**.81**	24.07	.00**	20.80	.00**
T-88 originality	60	47	1.12	.77	-4.88	**1.52**	**.82**	**.40**	**.53**	2.88	.58	1.76	.19	25.39	.00**	24.28	.00**
Self-report 'creative'	61	49	2.58	.46	-3.42	3.11	.54	.53	.47	**2.75**	**.60**	**.17**	**.68**	13.51	.02*	10.94	.00**
Peer-report 'creative'	62	49	1.71	.64	-4.29	3.32	.51	1.61	.20	**1.71**	**.79**	**.00**	**#**	6.62	.25	4.91	.09
Creativity factor 1	53	43	1.14	.77	-4.86	**1.40**	**.84**	**.26**	**.61**	1.42	.84	.28	.60	10.54	.06	9.40	.01*
Creativity factor 2	53	43	.13	.99	-5.87	**.14**	**1.00**	**.00**	**.96**	2.59	.63	2.45	.12	19.40	.00**	19.27	.00**

Note: * $p < .05$, ** $p < .01$, #: incalculable.
MZ = monozygotic, DZ = dizygotic.
Best fitting model is printed in bold face.
All analyses were based on values corrected for age and sex effects.
Variables corrected for all predictors were additionally corrected for N, E, O, A, C, P, g, g_f, & g_c.

Table 28
Fit of Univariate ADE Models to Creativity Indicators, Factors, and Predictors

	N (pairs)		ADE			AE				DE				E			
	MZ	**DZ**	χ^2	**p (df = 3)**	**AIC**	χ^2	**p (df = 3)**	**LRT**	**p (df = 3)**	χ^2	**p (df = 4)**	**LRT**	**p (df = 1)**	χ^2	**p (df = 5)**	**LRT**	**p (df = 2)**
Creativity indicators:																	
Self-report 'creative'	318	161	1.54	.67	-4.46	2.33	.68	.80	.37	**2.13**	**.71**	**.59**	**.44**	88.59	.00**	87.05	.00**
Predictors:																	
O (aggregated)	223	84	.66	.88	-5.34	**.85**	**.93**	**.19**	**.66**	1.65	.80	.99	.32	90.40	.00**	89.74	.00**
C (aggregated)	223	84	7.98	.05*	1.98	8.79	.07	.80	.37	**8.25**	**.08**	**.26**	**.61**	81.90	.00**	73.91	.00**
Indicators corrected for all predictors:																	
Video ratings 'creative'	59	45	1.40	.71	-4.61	2.19	.70	.80	.37	**1.40**	**.85**	**.00**	**#**	10.96	.05	9.57	.01*
Creativity g factor	53	43	.68	.88	-5.33	1.40	.84	.73	.39	**.68**	**.95**	**.00**	**.99**	18.97	.00**	18.29	.00**

Note: * p < .05, ** p < .01, #: incalculable.
MZ = monozygotic, DZ = dizygotic.
Best fitting model is printed in bold face.
All analyses were based on values corrected for age and sex effects.
Variables corrected for all predictors were additionally corrected for N, E, O, A, C, P, g, g_f, & g_c.

Fits of more parsimonious nested submodels were tested by fixing one or two paths from latent constructs to zero. Results yielded AE and CE or DE models as tenable for most variables, except for E, g_f and g_c, where AC models were unlikely, and T-88 originality, where all models deviated significantly from the data. The latter resulted from higher intra-pair resemblance in DZ than in MZ twin pairs, a pattern for which no reasonable model is known. Therefore, it seems likely that this pattern must be attributed to sampling error. A model assuming only a non-shared environmental influence (E model) was only acceptable for corrected peer and video ratings as well as the corrected first creativity factor.

The best-fitting model was found by testing nested submodels against the full model, using likelihood ratio tests (chi-squared difference tests; LRT) as well as comparing the AIC of the models, which is a fit index that takes the parsimony of the model into account. The final decision (based on the AIC) is set off in bold face in tables 27 and 28. For each variable, the relative size of the latent constructs' influence were estimated for the full and the best-fitting reduced model. These estimates are reported with 95% confidence intervals in table 29. Unlike in the reduced models, confidence intervals for the estimates of A and C or D effects in the full models almost exclusively included zero. Obviously, statistical power was too low to simultaneously support both kinds of effects.

Individual differences in both T-88 scoring dimensions and the resulting creativity factor 2 were best explained by shared and non-shared environmental influences only, with both being of equal strength for elaboration and the second creativity factor, and one third shared to two third non-shared environmental influences for originality. On the other hand, results indicated genetic and non-shared, but no shared, environmental influences on the remaining creativity indicators and factors. Genetic influences appeared to be additive for these variables (suggesting an inheritance by quantitative trait loci; Plomin et al., 1997), with the exception of self-reported creativity, where a model assuming 49% non-additive dominance effects and 51% non-shared environmental effects fitted best. Additive genetic effects were strongest on the general creativity factor (61%) and weakest on peer-reported creativity (29%).

Genetic and solely non-shared environmental effects were also the most likely and parsimonious explanation for E, O, C and the three intelligence factors, with all genetic effects but those on C being additive. Parameter estimates indicated roughly half genetic and half non-shared environmental influences on personality dimensions, and 72% to 80% additive genetic effects on g, g_f and g_c.

Table 29
Parameter Estimates from Univariate Analyses

	Full model				Best fitting nested model			
	A²	c²	d²	e²	a²	c²	d²	e²
Creativity indicators:								
T-88 elaboration	.00 (.00 - .40)	.46 (.09 - .55)	-	.53 (.44 - .63)	-	.47 (.37 - .55)	-	.53 (.45 - .63)
T-88 originality	.16 (.00 - .46)	.18 (.00 - .40)	-	.66 (.54 - .79)	-	.31 (.20 - .41)	-	.69 (.59 - .80)
Self-report 'creative'	.23 (.00 - .55)	-	.26 (.00 - .56)	.51 (.44 - .60)	-	-	.49 (.40 - .57)	.51 (.43 - .60)
Peer-report 'creative'	.23 (.00 - .29)	.05 (.00 - .31)	-	.71 (.61 - .82)	.29 (.19 - .39)	-	-	.70 (.61 - .81)
Video ratings 'creative'	.38 (.05 - .65)	.19 (.00 - .46)	-	.43 (.34 - .54)	.58 (.48 - .66)	-	-	.42 (.34 - .52)
Creativity factor 1	.56 (.00 - .70)	.01 (.00 - .48)	-	.44 (.30 - .64)	.56 (.38 - .70)	-	-	.44 (.30 - .62)
Creativity factor 2	.22 (.00 - .65)	.29 (.00 - .58)	-	.49 (.34 - .70)	-	.45 (.29 - .59)	-	.55 (.41 - .71)
Creativity g factor	.59 (.06 - .74)	.02 (.00 - .46)	-	.39 (.26 - .57)	.61 (.44 - .74)	-	-	.39 (.26 - .56)
Predictors:								
E (aggregated)	.54 (.22 - .63)	.00 (.00 - .28)	-	.46 (.37 - .56)	.54 (.44 - .63)	-	-	.46 (.37 - .56)
O (aggregated)	.40 (.00 - .64)	-	.17 (.00 - .64)	.43 (.35 - .53)	.57 (.47 - .65)	-	-	.43 (.35 - .53)
C (aggregated)	.20 (.00 - .61)	-	.34 (.00 - .62)	.46 (.38 - .56)	-	-	.54 (.44 - .62)	.46 (.37 - .56)
g	.68 (.44 – .84)	.12 (.00 - .35)	-	.20 (.15 - .25)	.81 (.75 - .85)	-		.19 (.15 - .25)
g_f	.59 (.32 - .77)	.13 (.00 - .38)	-	.28 (.22 - .35)	.72 (.65 - .78)	-	-	.28 (.22 - .35)
g_c	.59 (.34 - .80)	.17 (.00 - .40)	-	.24 (.19 - .31)	.76 (.69 - .81)	-	-	.24 (.19 - .31)
Indicators corrected for all predictors:								
T-88 elaboration	.07 (.00 - .60)	.37 (.00 - .57)	-	.56 (.38 - .74)	-	.42 (.25 - .57)	-	.58 (.43 - .75)
T-88 originality	.38 (.00 - .69)	.16 (.00 - .55)	-	.46 (.31 - .68)	.55 (.36 - .69)	-	-	.45 (.31 - .64)
Self-report 'creative'	.14 (.00 - .54)	.20 (.00 - .46)	-	.66 (.46 - .87)	-	.31 (.13 - .47)	-	.69 (.53 - .87)
Peer-report 'creative'	.00 (.00 - .37)	.21 (.00 - .38)	-	.79 (.61 - .98)	-	.21 (.02 - .38)	-	.79 (.62 - .98)
Video ratings 'creative'	.00 (.00 - .52)	-	.38 (.00 - .56)	.62 (.44 - .85)	-	-	.38 (.15 - .56)	.62 (.44 - .85)
Creativity factor 1	.19 (.00 - .55)	.16 (.00 - .47	-	.65 (.45 - .88	.37 (.14 - .56)	-	-	.63 (.44 - .86)
Creativity factor 2	.50 (.00 – 68)	.02 (.00 - .32)	-	.48 (.32 - .71)	.52 (.31 - .68)	-	-	.48 (.32 - .69)
Creativity g factor	.01 (.00 - .66)	-	.52 (.00 - .68)	.47 (.32 - .69)	-	-	.53 (.32 - .68)	.47 (.32 - .68)

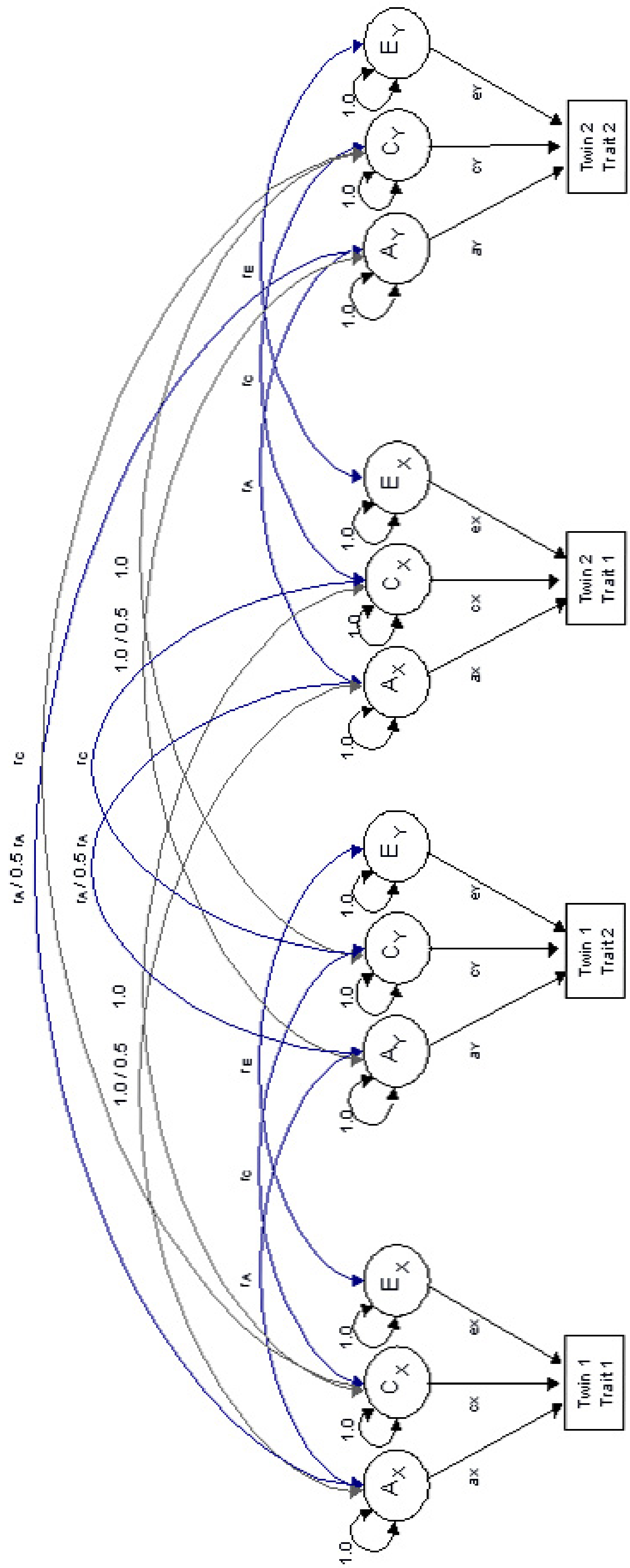
Note: 95% Confidence intervals in braces.
All analyses based were on values corrected for age and sex effects.
Variables corrected for all predictors were additionally corrected for N, E, O, A, C, P, g, g_f, & g_c.

The surprising effects of statistically controlling personality dimensions and intelligence factors on the etiology of dispositional creativity reappeared in the structure equation models: While T-88 elaboration remained best fitted by a CE model, originality and creativity factor 2 suddenly showed about 50% additive genetic instead of shared environmental influences. The residuals of creativity self- and peer-reports were no longer heritable, but influenced by the shared environment (31% and 21%, respectively). Video ratings and the creativity g factor, both formerly determined to about 60% by additive genetic sources, were determined by non-additive genetic sources (to 38% and 53%) after all predictors were partialled out. Creativity factor 1 remained additively heritable, though to a slightly lower degree.
Taken altogether, the following picture emerged: Individual differences in T-88 scores and the resulting creativity factor 1 appeared only determined by environmental effects, while all indicators based on molar creativity ratings, their resulting factor, and the common core they share with the T-88 dimensions (the creativity general factor) were weakly to moderately heritable, but lacked signs of shared environmental influences. Their assumingly causal predictors were all moderately (personality dimensions) to highly (intelligence factors) heritable, but also unaffected by the shared environment. When these predictors were controlled, only creativity self- and peer-reports lost their genetic foundation, while originality and consequently factor 2 lost environmental influences and became heritable. Genetic effects on the video-based stranger ratings as well as on the first and the general creativity factor were slightly reduced, with the video ratings and the g factor no longer suggesting an additive mode of inheritance.

3.2.5.2 Bivariate behavioral genetic analyses

These rather odd relations between dispositional creativity and its predictors might be illuminated by fitting bivariate models to the data. The model applied in this study, a correlated factors model (Neale & Cardon, 1992, p. 252), is shown in figure 8. Its basic logic is to compare the prediction of trait 1 in one twin from trait 2 in its co-twin (and vice versa) for MZ and DZ twins. Statistically, it is equivalent to the classic Cholesky decomposition (Loehlin, 1996), but it allows the estimation of two different

Figure 8
Bivariate Genetic ACE Model



kinds of informative coefficients: First, the genetic, shared environmental and non-shared environmental correlations (r_A, r_C and r_E), indicative of an overlap of the corresponding sources of variance, i.e. the degree to which individual differences in two characteristics are influenced by identical sources. Second, the bivariate heritabilities and shared and non-shared environmental mediations ($_{biv}h^2$, $_{biv}c^2$ and $_{biv}e^2$), resulting from the decomposition of phenotypical (observable) covariances of two characteristics, and indicative of the corresponding latent source's mediating effect on the phenotypic relation. Both kinds of coefficients are independent of each other. For example, two correlated traits might be influenced by exactly the same genes (perfect r_A), but when both traits have very low heritabilities (of whom r_A is independent), their association will not be mediated by this shared genetic foundation (low $_{biv}h^2$, which is $a_x * r_a * a_y$ in figure 8), but by overlapping environmental influences.

A bivariate genetic model has two minimal requirements: Both traits must be (1) phenotypicaly correlated (r_P), and (2) show influence by the same latent sources. The first requirement was met by the following relations of interest: Creativity factor 1 with factor 2, both before and after controlling for all predictors, creativity factor 1 with each E, O, g and g_f (g_c was excluded since it did not show a significant zero-order correlation), creativity factor 2 with E, O, C, g and g_c, and the creativity general factor with E, O, g and g_f. C was recoded for this analysis (high values now indicate low Conscientiousness) to ease the interpretability of results. E, O and C did not show shared environmental influences in the univariate analyses, therefore partially failing the second requirement. Thus, only bivariate AE models were fitted here. For all other analyses, full bivariate ACE models were justifiable. Again, full models were tested against nested submodels to receive the best-fitting model.

Fit statistics are listed in table 30. Where applicable, the ACE model showed a good fit to the data, as did the AE model for the remaining cases. However, LRTs suggested reduced models being superior over the full ACE model, and AICs indicated an AE model fitting the data best in all cases.

Table 31 gives parameter estimates for the full and the best-fitting reduced model. Due to limited statistical power, confidence intervals for the full model were again huge. Consequently, these estimates lacked meaningful interpretability, though they were already in line with a greater importance of additive genetic effects. In the following, only results from the better fitting AE model will be discussed.

Table 30
Fit of Bivariate ACE Models to Creativity Indicators, Factors, and Predictors

	N (pairs)		ACE			AE				CE				E			
	MZ	DZ	χ^2	p (df = 11)	AIC	χ^2	p (df = 14)	LRT	p (df = 3)	χ^2	p (df = 14)	LRT	p (df = 3)	χ^2	p (df = 17)	LRT	p (df = 6 / 3)
Creativity factor 1 X 2	63	44	15.22	.17	-6.78	**17.67**	**.22**	**2.44**	**.49**	20.57	.11	5.35	.15	65.19	.00**	49.97	.00**
Creativity factor 1 X E	61	44	-	-	-	**9.11**	**.82**	**-**	**-**	-	-	-	-	45.85	.00**	36.74	.00**
Creativity factor 1 X O	61	44	-	-	-	**14.33**	**.43**	**-**	**-**	-	-	-	-	52.97	.00**	38.64	.00**
Creativity factor 1 X g	55	43	5.70	.89	-16.30	**7.40**	**.92**	**1.70**	**.64**	19.91	.13	14.21	.00**	99.01	.00**	93.31	.00**
Creativity factor 1 X g_f	61	43	11.37	.41	-10.63	**13.54**	**.49**	**2.17**	**.54**	24.25	.04*	12.88	.00**	96.85	.00**	85.48	.00**
Creativity factor 2 X E	61	44	-	-	-	**9.55**	**.79**	**-**	**-**	-	-	-	-	47.37	.00**	37.82	.00**
Creativity factor 2 X O	61	44	-	-	-	**14.56**	**.41**	**-**	**-**	-	-	-	-	57.89	.00**	43.33	.00**
Creativity factor 2 X C-	61	44	-	-	-	**10.27**	**.74**	**-**	**-**	-	-	-	-	50.18	.00**	39.91	.00**
Creativity factor 2 X g	55	43	12.50	.33	-9.50	**14.92**	**.38**	**2.42**	**.49**	22.17	.08	9.66	.02*	101.68	.00**	89.18	.00**
Creativity factor 2 X g_c	61	43	9.29	.60	-12.72	**11.06**	**.68**	**1.77**	**.62**	22.18	.08	12.90	.00**	96.22	.00**	86.94	.00**
Creativity g factor X E	61	44	-	-	-	**9.75**	**.78**	**-**	**-**	-	-	-	-	56.00	.00**	46.25	.00**
Creativity g factor X O	61	44	-	-	-	**20.03**	**.13**	**-**	**-**	-	-	-	-	67.18	.00**	47.15	.00**
Creativity g factor X g	55	43	10.25	.51	-11.75	**11.75**	**.63**	**1.51**	**.68**	24.85	.04*	14.61	.00**	106.06	.00**	95.81	.00**
Creativity g factor X g_f	61	43	13.42	.27	-8.58	**14.65**	**.40**	**1.23**	**.75**	26.70	.02*	13.28	.00**	102.87	.00**	89.46	.00**
Creativity factor 1 X 2, all predictors contr.	53	43	8.51	.67	-13.50	**11.63**	**.64**	**3.12**	**.37**	13.71	.47	5.21	.16	39.47	.00**	30.97	.00**

Note: * p < .05, ** p < .01, #: incalculable.
MZ = monozygotic, DZ = dizygotic.
Best fitting model is printed in bold face.
All analyses based on values corrected for age and sex effects.
Variables corrected for all predictors were additionally corrected for N, E, O, A, C, P, g, g_f, & g_c.

Table 31
Parameter Estimates from Bivariate Analyses

	r_P	Full ACE model						Best fitting nested model (AE)			
		r_A	r_C	r_E	$_{biv}h^2$	$_{biv}c^2$	$_{biv}e^2$	r_A	r_E	$_{biv}h^2$	$_{biv}e^2$
Creativity Factor 1 X 2	.29	1.00 (-1.0 -1.0)	-1.00 (-1.0 - 1.0)	.09 (-.13 - .33)	.34 (117%)	-.09 (-31%)	.04 (14%)	.43 (.15 - .67)	.12 (-.12 - .34)	.24 (83%)	.05 (17%)
Creativity Factor 1 X E	.28	-	-	-	-	-	-	.15 (-.26 - .47)	.40 (.18 - .58)	.07 (25%)	.21 (75%)
Creativity Factor 1 X O	.45	-	-	-	-	-	-	.48 (.18 - .72)	.41 (.20 - .58)	.24 (53%)	.21 (47%)
Creativity Factor 1 X g	.27	.55 (-.05 - 1.0)	1.00 (-1.0 - 1.0)	-.10 (-.34 - .17)	.30 (111%)	.00 (0%)	-.03 (-11%)	.44 (.20 - .65)	-.09 (-.33 - .17)	.30 (111%)	-.03 (-11%)
Creativity Factor 1 X g_f	.33	.90 (.24 - 1.0)	-1.00 (-1.0 - 1.0)	-.09 (-.31 - .15)	.44 (133%)	-.08 (-24%)	-.03 (-9%)	.54 (.32 - .73)	-.07 (-.30 - .17)	.36 (106%)	-.03 (-9%)
Creativity Factor 2 X E	.22	-	-	-	-	-	-	.13 (-.26 - .45)	.31 (.08 - .50)	.06 (27%)	.16 (73%)
Creativity Factor 2 X O	.38	-	-	-	-	-	-	.36 (.04 - .61)	.40 (.19 - .57)	.18 (47%)	.20 (53%)
Creativity Factor 2 X C-	.12	-	-	-	-	-	-	.18 (-.16 - .50)	.06 (-.17 - .29)	.09 (75%)	.03 (25%)
Creativity Factor 2 X g	.25	.21 (-1.0 - 1.0)	.62 (-1.0 - 1.0)	.07 (-.19 - .33)	.08 (32%)	.15 (60%)	.02 (8%)	*.36* *(.12 - .58)*	.05 (-.20 - .30)	.23 (92%)	.02 (8%)
Creativity Factor 2 X g_c	.31	.12 (-1.0 - 1.0)	1.00 (-1.0 - 1.0)	.21 (-.04 - .44)	.05 (16%)	.20 (65%)	.06 (19%)	*.38* *(.14 - .59)*	.18 (-.06 - .41)	*.25* *(81%)*	.06 (19%)
Creativity g Factor X E	.32	-	-	-	-	-	-	*.16* *(-.23 - .45)*	.48 (.28 - .64)	*.08* *(25%)*	.24 (75%)
Creativity g Factor X O	.52	-	-	-	-	-	-	.50 (.23 - .71)	.54 (.35 - .68)	.26 (50%)	.26 (50%)
Creativity g Factor X g	.32	.44 (-.09 - 1.0)	1.00 (-.71 - 1.0)	-.03 (-.28 - .23)	.25 (78%)	.08 (25%)	-.01 (3%)	.47 (.25 - .66)	-.03 (-.28 - .22)	.33 (103%)	-.01 (-3%)
Creativity g Factor X g_f	.34	.67 (.13 - 1.0)	1.00 (-1.0 - 1.0)	-.08 (-.31 - .17)	.36 (106%)	.00 (0%)	-.02 (-6%)	.55 (.34 - .73)	-.07 (-.30 - .17)	.36 (106%)	-.02 (-6%)
Creativity Factor 1 X 2, all Predictors contr.	.21	1.00 (.13 - 1.0)	-1.00 (-1.0 - 1.0)	.06 (-.17 - .29)	.30 (143%)	-.13 (-62%)	.04 (19%)	.37 (-.03 - .76)	.07 (-.18 - .31)	.17 (81%)	.04 (19%)

Note: 95% Confidence intervals in braces.
All analyses were based on values corrected for age and sex effects.
Variables corrected for all predictors were additionally corrected for N, E, O, A, C, P, g, g_f, & g_c.

Note that phenotypic correlations (r_P) in table 31 differ somewhat in size from those reported in tables 17 and 18 because of small sample variations and a different calculation procedure.

The additive genetic sources acting on creativity factor 1 and 2 correlated moderately (.43). This considerable overlap resulted in 83% of the phenotypic correlation being mediated genetically. After controlling all predictors in both factors, the latent pattern remained unaltered, only the phenotypic correlation was lower. The etiology of the relation between E and O on the one side and the three creativity factors on the other was very similar: Genetic correlations between E and all three factors were low (.13 to .16, while genetic correlations between O and all factors, as well as non-shared environmental correlations between both E and O and all factors were moderate (.31 to .54). The phenotypic correlation of E with the creativity factors (.22 to .32) was always mediated to one quarter by genetic and to three quarters by non-shared environmental effects. The higher observed correlation between O and the factors (.38 to .52), on the other hand, was mediated by equally by genetic and non-shared environmental effects in each case. C shows only weak genetic and environmental correlations with the second creativity factor, but the phentotypic correlation was also small (.12). It decomposed into three quarters genetic and one quarter non-shared environmental mediation. The genetic correlations of g and its facet g_c were .36 and .38, respectively, while the non-shared environmental ones were low (.18) for g_c and effectively zero for g. Therefore, genetic effects were responsible for 92% of the correlation with g and 81% of those with g_c. Similarly, the genetic correlations of g and g_f with the first and the general creativity factor were moderate (.44 to .55), while the shared environmental ones were even slightly negative. This resulted in genetic effects being the only link between these factors, i.e. a genetic mediation of 100%.

It has to be remarked that, because of the small sample size for a multivariate analysis, most confidence intervals included zero. Taking them into account, what can be safely concluded is that the genes influencing Openness to Experience as well as general intelligence and its facets, and the non-shared environmental effects acting on Openness and Extraversion, overlapped with those influencing dispositional creativity. On the same rational, partly identical genes influenced both creativity factor 1 and 2, at least as long as personality and intelligence predictors were not controlled.

3.3 Discussion

Supporting hypothesis 1, all indicators of a disposition towards creativity used in this study showed significant intercorrelations. Even though the T-88 was a derivate of an divergent test, all indicators were based on subjective ratings of creativity or some of its components, therefore following Amabile's (1982) consensual definition. The indicators were very different in the kind, amount and standardization of information accessible to the judges, as well as the length of acquaintanceship between judge and target subject: They ranged from self ratings to ratings of well acquainted peers, which had plenty of opportunities to form themselves a picture of the subject over many years, to strangers who saw the subject for the first time in a few minutes long, standardized situation on video tape, to raters who had nothing more than eighteen entitled line drawings of a subject they never met. Additionally, different indicators were assessed at different times, with about five years lying between the first (self- and peer-reports) and the last (T-88) assessment of creativity. The indicators themselves were aggregates of one to sixty independent judges, all of which showed considerable consensus. That creativity judgments of normal adult persons under all these diverse conditions had enough in common to allow the extraction of a general factor which explained over 40% of the indicators' variance is indeed impressive. Because of the variety of measurement methods and times contributing to it, diverse sources of measurement error have likely been attenuated. This result leaves no doubt that something like a relatively stable disposition towards creativity does exist in normal people. That this general disposition splitted into two factors has several possible explanations: Compared to the self and peer ratings marking creativity factor 1, the T-88 marking factor 2 was later assessed, more divergent test-like (though not identical, see chapter 2) and based on fewer and more standardized information. The video-based stranger ratings, which showed substantial loadings on both factors, laid in between.

In line with hypothesis 2, all three creativity factors correlated low to moderately with general intelligence. This result underlines that creativity and intelligence are far from being identical, but also contradicts their fundamental independence aside from professional requirements, as suggested in the 'certification hypothesis' (Hayes, 1989). The differentiation of general intelligence into its fluid and crystallized facets shed a bit light into the distinction of the two creativity subfactors: Only fluid

intelligence was supportive for the creativity aspects represented by factor 1 (with genuine crystallized intelligence even having a slight detrimental effect), and only crystallized intelligence affected factor 2. Paralleling this, creativity self-concept and the peer perceptions, which were the markers of the first factor, were only (weakly) affected by genuine fluid intelligence, while the two T-88 scores, marking factor 2, showed a stronger influence of crystallized intelligence aspects. The video-based stranger ratings, which loaded on both factors, were equally influenced by all facets of general intelligence. Since, as the regression analyses revealed, personality influences were rather similar for both factors (except for low C acting on factor 2, see below), different demands on fluid relative to crystallized intelligence might have been the prime difference between the two creativity factors found in this study. Mere effects of measurement time, on the other hand, seem unlikely. The demands of the creativity indicators might be better candidates: Maybe more standardized, test-like conditions, especially when responses are judged by a stranger (to whom your old ideas and jokes are unfamiliar), allow for creative solutions to appear out of old knowledge (g_c), while observed real-life behavior in spontaneous tasks and interactions does not, but instead requires quick combination of various information (g_f). The antagonistic effects of g_f and g_c found in both factors is in line with this interpretation, also confirming the negative transfer effect of g_c on creativity proposed by Cattell (1971). The general creativity factor was subsequently affected by both intelligence facets, with a slight superiority of genuine fluid over genuine crystallized aspects. Interestingly, these results support Cattell’s (1971) suggestion of fluid intelligence as the fundament of everyday creativity, but also explain the findings of Crawford (1974) and Crawford and Nirmal (1976), which showed divergent tests being stronger related to crystallized intelligence. The popular ‘threshold hypothesis’, on the other hand, was again not supported in this study: The relationship between general intelligence and all three intelligence factors was perfectly linear.

A very clear picture emerged for the strongest relation of a personality dimensions to dispositional creativity: As predicted, Openness to Experience showed consistently the highest correlations with all creativity factors, making it the best single predictor of a disposition towards creativity. The second best, incremental personality predictor was Extraversion, except for creativity factor 2, where low Conscientiousness did even better. It is interesting that the supportive effect of low C seems to go hand in hand with that of g_c. A possible interpretation would be that learned knowledge is

only able to bear new, creative outcomes when handled in a playful, unorganized, not very goal-directed or even mildly chaotic manner. Extraversion, on the other hand, seemed to be especially important for creativity indicators based on directly observed behavior. Its unique contribution might therefore be due to a facilitation of displaying one's ideas to an audience. This would mirror Feist's (1998) finding of the confidence/dominance aspect of Extraversion being more important than the sociability aspect for professional creative achievement. But since the results of this study were not sufficiently differentiated, such an interpretation remains speculative. On the other hand, communality analyses did show that not the common core of Extraversion and Openness to Experience, but the Openness variance independent of Extraversion was most predictive for all three creativity factors. If indeed a dopaminergic neuronal system, mediated by latent inhibition, underlies the common core of Openness and Extraversion (Peterson et al., 2002), than it can only be a partial explanation of why Openness relates to dispositional creativity. Since the other personality dimension proposed to relate to both dopamine/latent inhibition and dispositional creativity, Psychoticism (Eysenck 1993, 1995a, b), did even worse as a predictor of dispositional creativity, as did synergistic effects of these dimensions with general intelligence, we are left with the latent inhibition mechanism being only an incomplete account for dispositional creativity, and we are left with only an partial explanation of why Openness to Experience does relate to dispositional creativity. I will return to the latter point in the general discussion (chapter 4). Anyway, these conclusions are only indirect, since latent inhibition was not measured in this study. A further comment has to be made about Psychoticism, since two more technical explanations for its failure to relate to creativity in this study are possible: First, reliabilities (internal consistencies) of both self- and peer-reports were at the lower edge of what is acceptable for a scientific study. But since correlations with creativity were virtually zero, disattenuating them cannot be expected to make much difference. Second, a more critical point can be made about the EPQ P scale in general: As noted by Harrington (1993), its unclear relation to psychotic symptom susceptibilities (like latent inhibition), diverse item content, multifactorial nature and, maybe most important, substantial revision in 1985 (Eysenck, Eysenck & Barrett, 1985), make the evidence about its relations to creativity hard to interpret. To my knowledge, only Wuthrich and Bates (2001) and the present study related the revised version of the P scale to a non-achievement measure of creativity – both with

negative results. The meta-analytic association of creative achievement and P found by Feist (1998), assumingly incorporating results from both versions of the P scale, might therefore indicate that (at least) the revised version measures something that facilitates a creative career, not creativity per se.

While in this study certain personality and ability dimensions explained up to one third of the variance in the dispositional creativity factors, at least two thirds of these relatively unbiased estimates (see above) remained unexplained by them. Indeed, controlling for all the comprehensive dimensions of individual differences assessed in this study did somewhat reduce the intercorrelations of the creativity indicators (which can be taken as pseudo-criteria for each other), but did not alter their factor structure. Since most residuals did not drop in heritability (this was only true for self- and peer-reported creativity and consequently factor 1), but even gained genetic influence (T-88 originality and factor 2) or suddenly exhibited signs of non-additive inheritance (video ratings and the general factor), the controlled personality and ability dimensions cannot be regarded as necessary determinants of a disposition towards creativity.

Behavioral genetic analyses revealed a complex etiology for dispositional creativity. In one of its aspect (factor 1), it was very similar to what is often found for personality traits – roughly 50% heritability, no effects of the shared, but substantial ones of the non-shared environment. The other aspect (factor 2) showed – in line with previous results on divergent tests – remarkable environmental effects of both the shared and non-shared kind (especially true for the elaboration component measured by the T-88) and only weak genetic influences, which failed to reach significance because of a lack of statistical power. But since bivariate analyses revealed a mainly additive genetic link between both creativity subfactors, their existence is likely. Additional evidence stem from the sudden appearance of genetic influences in substantial magnitude (combined with a disappearance of shared environmental effects) after the statistical control of personality and intelligence dimensions. However, this latter result is hard to interpret, especially since all controlled influences showed mainly additive genetic, but not shared environmental, associations with factor 2 in bivariate analyses. It surely awaits replication before a definite interpretation can be given. The consistent shared environmental effect on T-88 elaboration is special, since such effects are relatively pure estimates (heritabilities also include gene x shared environmental interactions, while non-shared environmental effects also include gene

x non-shared environmental interactions and measurement error; Purcell, 2002), which hold the promise of leading to isolatable critical environmental factors. Traits showing strong shared environmental are seldom found, but these results make a disposition to develop and enrich one’s ideas a likely candidate.

That creativity factor 1 and its indicators showed an etiological pattern typical for personality traits is not very surprising, since they were measured with methods most typical for personality research. Factor 1 simply reflected one’s self-concept and social appearance as creative. It must be remarked that the measurement of its indicators with single, direct items is no disadvantage, because people have a valid implicit concept of who is a creative person, and creativity research has so far failed to provide something better (see section 1.1). Influences of fluid intelligence on factor 1 were completely genetic, and also Openness to Experience and Extraversion contributed to it via shared genes, though common influences of the non-shared environment were also important here (especially for Extraversion). Controlling them reduced the heritability of factor 1 and revealed some weak shared environmental effects on the creativity self-concept and peer evaluation.

Arguably interpretable as the very core disposition towards creativity, the general factor showed a considerable heritability of 61%. Such a strong genetic influence differed markedly from what has been reported for creativity so far (section 1.5) and underlines that divergent test results should not simply be taken as representative for creativity. Influences of its predictors fluid and general intelligence, Openness to Experience and Extraversion took the same pathways in a similar pattern as they did in the case of the first creativity factor, especially emphasizing shared genes with general intelligence and Openness. However, controlling these influences had substantial reductive effects on the pair resemblance of DZ, but not MZ twins, and thus brought forth further non-additive genetic effects. The video ratings exhibited a similar pattern. Since assortative mating effects can be expected for dispositional creativity, it is likely that all genetic effects reported here were attenuated, while shared environmental ones were inflated (confirm section 1.5). Taking this into account would suggest that the genetic effects on general dispositional creativity beyond those attributable to general intelligence, Openness and Extraversion were unshared by relatives except identical twins, i.e. they were emergenic. Note that this result differs markedly from those of Canter (1973), who found very similar correlations for MZ and DZ twin pairs in divergent test performance after controlling

for general intelligence (separate analyses not reported so far indicated that the general creativity factor remained heritable to 55% when only general intelligence was controlled).

To summarize, what made the subjects of this study creative was largely general intelligence, Openness to Experience, Extraversion, a bit low Conscientiousness and some unspecified idiosyncrasies stemming from synergistically interacting genes. But most importantly, dispositional creativity was substantially heritable. Since this result clearly contradicts the current view, I hope it encourages further inquiries into this underdeveloped area.

Several limitations of this study should also be mentioned. First of all, while this study already used multiple indicators of dispositional (everyday) creativity, further ones, like assessments of creative hobbies, activities and non-professional accomplishments (see Hocevar, 1980; Carson et al., 2003; King et al., 1996; Wolfradt & Pretz, 2001) or retrospective reports of one's lifetime creativity (Richards et al., 1988) would be helpful for getting a less biased and more valid criterion. Such an approach would be especially urgent for behavioral genetic studies, where something like this has never been done. I doubt, however, that such methods can be valid without relying on subjective judgments of creativity, an aspect excessively considered in the present study. On the other hand, unlike most studies, the present one assessed personality via two peer-reports additionally to self-reports. Method effects were therefore much better controlled than in the majority of previous attempts to relate creativity to personality. Behavioral genetic studies of adult personality have also been criticized for relying solely on self-reports (Brody, 1993), making the present etiological inquiry into the relation of creativity to adult personality even more valuable. Second, like in most twin studies, a larger number of twin pairs would have allowed to receive more reliable parameter estimates in the structure equation models. Third, measurement points for creativity indicators and predictors were spread over several years in an rather arbitrary manner. Since no developmental perspective was taken in here, a concurrent assessment of all variables would have been more appropriate for the aims pursued in this study. That the results came out as clearly as they did is therefore a positive surprise. Fourth, a removal of the T-88's uncontrollable time limit would have been a definite improvement. Studies like those of Ferris and colleagues (1971) have shown that both controlled, test-like and relaxed, untimed administrations of tests comparable to

the T-88 yielded valid results, but the same is unclear for a mix of administration conditions as the one that has happened here. Since test sheets suggested some individual differences in dealing with it, the T-88 results should interpreted with some care (though no hint to any form of directional error resulting from it was found in the analyses). Finally, all predictors of a disposition towards creativity were of a very broad kind. While this allowed a rather comprehensive overview of cognitive and personality effects acting on dispositional creativity, more fine-grained influences were blurred. These include a lack of insight into the relative effect of confidence/dominance and sociability aspects of Extraversion and the roles of classical divergent thinking, traits like sensation seeking or tolerance for ambiguity, and motivational dispositions. Facet-level analyses of the relevant NEO-PI-R scales would surely have been an informative first step in this direction.

4. General discussion and conclusion

In front of the results, we can now reconsider the central question from the very beginning: What makes a person creative? As already said in the last section, the superficial answer for everyday creativity in normal people that has emerged is: To over 60% his or her genes and to less than 40% his or her non-shared environment. Mainly a high Openness to Experience and general intelligence, plus a bit Extraversion and a pinch of low Conscientiousness. But why? A high Openness to Experience, which without doubt holds the lion's share, might be supportive in several ways: First, it might be an indicator of increased dopaminergic activity in the frontal lobe and mesolimbic system, resulting in a lowered latent inhibition that allows more information to enter the focus of attention. This additional information can, following Campbell (1960) and Simonton (1988, 1999b), be beneficial for more and more unusual ideational variation as a result of blind mental combinatory processes, which can be selectively retained as creative sparks. But as mentioned before, if this is only true for the common core of Openness and Extraversion, it explains only a part of the Openness influence. Other important elements of Openness to Experience include intellectual curiosity, active imagination, unconventional attitudes, preferences for novelties and independence in opinion-formation (McCrae, 1994; Angleitner & Ostendorf, 2003), all of which are supportive for entering more and more unusual information into the blind mental combinatory process, though in a more active manner than simply perceiving more information from the environment. Additionally, Openness to Experience is related to divergent thinking, which is mainly ideational fluency (Hocevar, 1979a, b). Fluency can be seen as the speed of the variation generator. Here, we slowly reach common ground with general intelligence. The fluid aspect of general intelligence is beneficial because it allows the extraction of more complex information from the environment, faster learning of new information in new environments, the faster combination (mental speed) of more information units (working memory capacity), and, last but not least, a better evaluation of what is a reasonable result in the selective-retention process. The crystallized facet, on the other hand, is responsible for the amount of older information that has been learned earlier and can now be entered into the blind combination process. However, as remarked by Cattell (1971), high crystallized intelligence is not solely beneficial, since it might lead to knowing an existing solution or behavior for most situations, therefore

hindering that a creative one results from fluid intelligence. Low Conscientiousness can introduce informational variation through its unsteady, chaotic and unsystematic nature, though a lack of goal-directedness and volition might be detrimental even for small creative acts in everyday life. Therefore, its net effect is only weak. Extraversion’s influence might either function via low latent inhibition, confidence and dominance to display one’s creative ideas, or it might facilitate the generation of ideational variation through positive affectivity (Isen, Daubman & Nowicki, 1987): A state of positive affect is marked by low cortical arousal, yielding an attenuation of dominant response patterns (Hull, 1943) and therefore allowing for creative ones.

While these personality and intelligence dimensions surely are the most important (and supposingly most common) single determinants of what makes a person creative, the results this study suggest that meaningful individual differences in everyday creativity exist independent of these factors. The behavioral genetic analyses have revealed that about half of these remaining differences stem from non-shared environmental influences, which could include pure chance events of creativity or be due to other hardly reconstructable causes. The other half, in contrast, appeared to be under the influence of genetic effects only shared by individuals with identical genome. What follows is that a substantial amount of creative behavior observable in everyday life results from behavioral idiosyncrasies of people, which in turn stem from interactions of heritable traits and individual genes. Despite the lack of an association between Eysenck’s Psychoticism dimension and creativity in this and several other studies (confirm section 1.3), and contrary to humanistic perspectives on creativity (Woodman, 1981), prime candidates remain various psychopathological disorders. Severe forms of disorders do without doubt lead at best to ‘novel’ ideas that lack usefulness or appropriateness – and therefore creativity. But there exist plenty of evidence from diverse sources that suggest the link between genius and madness (which goes far back to Aristotle) being more than just a myth (Simonton, 1999b; Prentky, 1989; Eysenck, 1995a). Both Eysenck and Simonton propose that mild forms of disorders have to pair up with high levels of ego-strength to allow for creativity to emerge. According to them, this is because the random ideational variation provided by the pathology, when controllable and selectively retained, can act as ideational raw material for creative products. Such interactions might therefore be possible pathways to idiosyncratic creativity. But they are surely not the only ones. As the Minnesota study of twins reared apart has shown

(Lykken et al., 1992), complex patterns of polymorphic behavior-influencing genes open up a universe of unique (except for one's MZ co-twin) behaviors and (via gene x environment interactions and correlations) experiences (Plomin et al., 1997; Bouchard, Lykken, Tellegen & McGue, 1996), all of which have the potential to facilitate the generation of novel and useful combinations of information.

This brings us back to a question I have raised on the very first page, but haven't reconsidered since: The heterogeneity of creativity. Contrary to the popular picture of creativity as a single, homogeneous trait in naïve - and often enough scientific - psychology, it now appears to be a heterogeneous disposition with multiple sufficient, but no necessary (though some fairly common) determinants (confirm Asendorpf, 1999, p. 178). Thus, what we are left with is a secondary Darwinian process at the very core of creativity, and various individual differences adjusting the amount and diversity of elements it can randomly combines as well as the efficiency with which it selects results that fit the task or situation. The heterogeneity of personality factors potentially contributing to a disposition towards a stochastic phenomenon called creativity (Simonton, 2003) might be the reason why creative genius has never lost the veil of mysticism which cloaked it ever since the term 'genius' was coined in ancient Greek (where it labeled the 'Daimon' or 'guardian spirit' that possessed all those with unexplainable creative abilities; Albert & Runco, 1999).

A final comment has to be added about the double role of general intelligence in the creative process: Unlike all the other potential determinants of dispositional creativity discussed in this thesis, general and especially fluid intelligence do not only facilitate the generation of ideational variation, but are of prime importance for the selective retention process. The level of reasoning ability a creator posses determines the complexity and amount of ideational combinations he can evaluate and the degree of fit he can achieve to often complex demands of the environment, task, fashion or existing information structure. A (theoretical) complete lack of general intelligence would result in arbitrary productions that completely lack fit – useless, inappropriate and therefore uncreative. This might indeed be the case in schizophrenia, where the evaluative mechanism is overwhelmed by the amount of generated variation (see e.g. Carson et al., 2003). What it implies is that, unlike all the other determinants, a certain amount of general intelligence cannot be substituted. The necessary amount is given by the field of creative endeavor: Completing a line drawing is fairly unconstrained, while making up an excuse why one is unable to help a friend (as in

one of the GOSAT video situations) is already constrained by rules of social behavior and perhaps by the cleverness of other person. Spontaneous jokes or witty comments normally require the quick integration of a new ideational combination into the actual situation in a surprising, yet meaningful manner. Pieces of art have to fit aesthetic preferences and often defining features of a style or fashion - acquired knowledge that has to be kept in mind as an evaluative standard for every stroke of the brush. And having a creative scientific insight requires picking the meaningful complex of information that fits a huge net of empirical evidence out of random combinations of diverse knowledge that float in the scientist's stream of consciousness.

Surely most of the creative tasks the subjects in the main study had to complete (and also the vast majority of divergent tests) do not require a high level of reasoning ability to manage the evaluative part of the creative process. It is unlikely that this part imposed high cognitive demands on the subjects. Thus the beneficial effect of general and fluid intelligence on dispositional creativity found in the main study might nearly exclusively stem from its facilitating effects on the variation generation process, making it replaceable. More complex forms of creative activities – professional as well as recreational ones – should be more dependent on a minimal level of general (fluid) intelligence. This should not be understood as an attempt to reintroduce the 'threshold' or the 'certification hypothesis' through the backdoor: In any case, more general intelligence is more beneficial in one or both ways it influences the creative process, without an upper limit. But what it implies is, given a minimal complexity level of the creative activity (i.e. demands of the activity to fit one's ideas to existing information) and an unrestricted range of both creativity and intelligence, the only thing that can be reliably inferred about a person from his creative performance is his level of general intelligence. This makes most creative performances, when compared to the whole population, valid cues of general intelligence. I therefore agree with the conclusion of Haensly and Reynolds (1989, p. 130): "Yet each creative act may be the ultimate expression of intelligence, in which all of the cognition and comprehension that individuals have developed at that point in their time (age) and situation (context) with their degree of training (experience) have been brought to bear upon a particular idea or problem. We propose that creativity is not another "breed" of mental processing, but is the ultimate expression of that finely honed system of thinking we know as intelligence."

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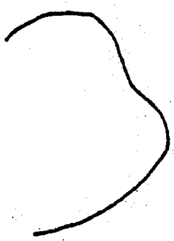
6. Appendix

6.1 The T-88

Für die folgende Aufgabe benötigen Sie eine Uhr mit Sekundenzeiger.

Zeichnungen ergänzen (T 88)

Sie sollen nun unvollständige Zeichnungen ergänzen.
Sie sehen auf den folgenden Seiten eine Reihe von Figuren, die einen Teil einer Zeichnung darstellen.
Vervollständigen Sie diese angefangenen Zeichnungen bitte so, daß Bilder entstehen, die Ihnen gut gefallen.
Wenn Sie mit einer Zeichnung fertig sind, schreiben Sie bitte auf die Linie unter jeder Zeichnung, was Sie mit dieser Zeichnung darstellen wollten. Fällt Ihnen nichts ein, machen Sie bitte einen Strich und gehen sofort zur nächsten Zeichnung weiter.
Sie sollten die gesamte Aufgabe innerhalb von vier Minuten bearbeiten.



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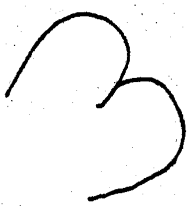

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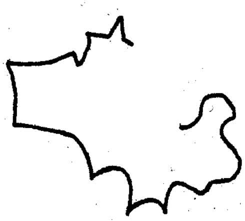

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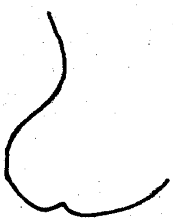

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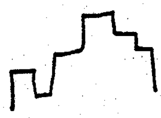

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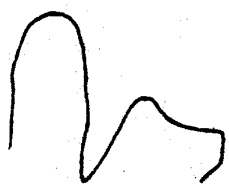

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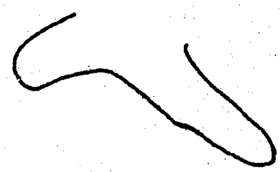

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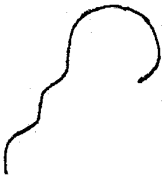

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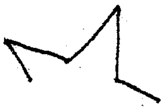

10.

11.

12.

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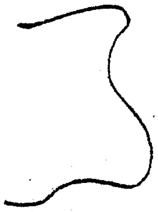

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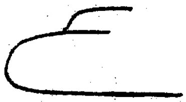

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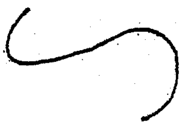

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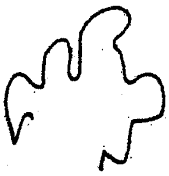

18.

Für den Fall, daß Sie weniger als 4 Minuten für die Lösung dieser Aufgabe benötigt haben, geben Sie bitte die von Ihnen benötigte Zeit an. Benötigte Zeit: _____ min _____ sec

6.2 Rater instructions for the T-88

Rater-Instruktionen

- Auf die richtige Kennummer beim Eintragen in den Ratingbogen achten
- Auf die Nummerierung der Items achten!
- Immer pro Heft zunächst ein Item für alle Versuchspersonen in diesem Heft auf beiden Dimensionen bewerten, dann das nächste Item
- Zeichnungen dürfen auch so ergänzt sein, dass das Bild auf der Seite liegt oder auf dem Kopf steht
- Sei möglichst durchgehend konsistent in Deiner Beurteilung
- Nutze die ganze Breite der Skala, sei also nicht zu mild oder streng.
- Vermeide auch zu häufige Extremurteile oder eine starke Tendenz zu mittleren Einschätzungen
- Es hilft, die Zeichnungen immer wieder mit den vorgegebenen Linien zu vergleichen.
- Achte darauf, wie gut Du Dich noch konzentrieren kannst, damit Du nicht in unterschiedlichen Zeichnungen immer die Standardantworten siehst!

Originalität ist die Fähigkeit, etwas zu produzieren, das einerseits neu (d.h. unkonventionell, unerwartet, ungewöhnlich, statistisch selten, einfallsreich) ist, andererseits aber auch einen Realitätsbezug hat (letzterer kann hier aber großzügig bewertet werden). Auch abstrakte Formen und Muster zählen, sollten aber eine gewisse ästhetische Qualität besitzen und nicht zufällig oder lustlos sein.

In ein Originalitätsrating einfließen sollte:
- Neuheit, Seltenheit, Originalität, Überraschung, ferne Assoziation (siehe Baselines)
- Die Idee, also der Inhalt (aus Zeichnung und evtl. Titel) und die Form

Nicht in ein Originalitätsrating einfließen sollten:
- Die Originalität der anderen Items einer Versuchsperson (also jedes Item einzeln, kein Gesamteindruck!)
- eigene Vorlieben oder Abneigungen
- die Qualität der Ausführung, im Sinne von Zeichenfähigkeit
- wie Ordentlich oder Unbeholfen die Ausführung ist
- fehlender Titel (ist egal)
- Handschrift, Rechtschreibfehler im Titel o.ä.

Elaboriertheit bezieht sich rein auf die Qualität der Ausführung, d.h. in der Regel, wie gut die Zeichnung erkennbar und wie detailliert und/oder künstlerisch sie ist. Bei Mustern und abstrakten Zeichnungen ist die Elaboriertheit subjektiv. Ob ein Titel gegeben wurde, die Handschrift etc. sind auch hier egal. Auch Zeichentechnik oder -übung sollte hier nicht einfließen.

Bei gleichen Titel können die Zeichnungen dennoch unterschiedlich elaboriert und/oder originell sein!

Die Skalen:

Elaboriertheit: 0-1-2

/ (9): Missing: Nicht bearbeitet oder nur durchgestrichen
0: Bearbeitet, aber nicht erkennbar (oder Zufallsproduktion)
1: Bearbeitet, erkennbar
2: Bearbeitet, erkennbar und verziert, verfeinert, mit Details, Schatteneffekten o. ä.

Originalität: 1-2-3-4-5

/ (9): Missing: Nicht bearbeitet oder nur durchgestrichen
1: Sehr arm. Plan- oder lustlos bearbeitet, Zufallsproduktionen oder sehr nah an den vorgegebenen Linien orientiert (extrem stimulusgebunden)
2: Arm. Nah an den vorgegebenen Linien (stimulusgebunden), banal und abgedroschen
3: Durchschnittlich. Gewöhnliche Zeichnung, die mittelmäßig von der Vorgabe entfernt ist
4: Überdurchschnittlich. Clever, gewitzt, ästhetisch
5: Sehr clevere oder ungewöhnliche Idee. Hat einen fesselnden Effekt

6.3 Response baselines for the T-88

Baselines: Top-Antworten Cut-Off: 5%

Item 1	% (korr.)
Wolke	9,36
Zahn	9,36
(Enten-)Teich, See	8,51
Apfel	6,81
Gesicht	6,38
Kartoffel	5,11
Summe	**45,53**
	% (unkorr.)
nichts o. unkenntlich	15,47

Item 5	% (korr.)
(Sand-)Burg / Festung	37,5
Skyline / Wolkenkratzer /Stadt	34,09
Haus / Fabrik	17,42
Summe	**89,01**
	% (unkorr.)
nichts o. unkenntlich	5,71

Item 2	% (korr.)
Herz	73,53
Po (von Frau o. Kind)	5,51
(Klee-)Blatt	5,15
Summe	**84,19**
	% (unkorr.)
nichts o. unkenntlich	2,16

Item 6	% (korr.)
Blume, Blüte, Tulpe	17,7
Krone	16,05
Mütze, Hut	7,82
Schmetterling	7,82
Summe	**49,39**
	% (unkorr.)
nichts o. unkenntlich	12,59

Item 3	% (korr.)
Blatt (angefressen etc.)	14,04
Fleck, Klecks	9,36
Seepferdchen	7,02
Drache	5,85
Landkarte	5,85
Summe	**42,12**
	% (unkorr.)
nichts o. unkenntlich	38,49

Item 7	% (korr.)
Kaktus	15,75
Hand	10,96
Glied / Penis	9,59
Gebirge	8,9
Summe	**45,2**
	% (unkorr.)
nichts o. unkenntlich	47,65

Item 4	% (korr.)
Nackte von hinten, weibl. Akt	34,57
Birne	14,4
Nase (eines Gesichtes)	11,52
Hund	7,82
Summe	**68,31**
	% (unkorr.)
nichts o. unkenntlich	12,9

Item 8	% (korr.)
Fuß	37,33
Hand	6,45
Bumerang	6,45
Summe	**50,23**
	% (unkorr.)
nichts o. unkenntlich	21,94

% (korr.): Prozentuale Anteile an den erkennbaren Antworten von bearbeiteten Items

Item 9	% (korr.)
Luftballon	43,64
Raupe / Wurm / Larve	7,73
Summe	**51,37**
	% (unkorr.)
nichts o. unkenntlich	20,86

Item 14	% (korr.)
Turm / Burg / Mauer (Zinnen)	40,68
Schiff	16,95
Eisenbahn / Lok	9,75
(Hoch-)Haus (mit Kamin)	8,9
Skyline / Stadt	6,36
Summe	**82,64**
	% (unkorr.)
nichts o. unkenntlich	15,11

Item 10	% (korr.)
Stern	93,45
Komet / Sternschnuppe	4
Summe	**97,45**
	% (unkorr.)
nichts o. unkenntlich	1,08

Item 15	% (korr.)
See / Pfütze / Teich	23,16
Gesicht / Kopf / Fratze	7,89
Spiegelei	6,32
Fahne	6,32
Wolke	6,32
Fleck / Klecks	5,79
Summe	**55,8**
	% (unkorr.)
nichts o. unkenntlich	31,65

Item 11	% (korr.)
(Vogel-)Fuss(abdruck)	60,19
Gespenst	5,83
See / Pfütze	5,83
Tier auf dem Kopf	5,34
Summe	**77,19**
	% (unkorr.)
nichts o. unkenntlich	25,9

Item 16	% (korr.)
Flugzeug	17,07
Fuss	17,07
UFO	16,67
Auto	12,6
Hut	6,1
Summe	**69,51**
	% (unkorr.)
nichts o. unkenntlich	11,51

Item 12	% (korr.)
Vogel / Ente	38,02
Flasche / Gefäß / Vase	24,48
Hut / Mütze / Haube	5,05
Summe	**67,55**
	% (unkorr.)
nichts o. unkenntlich	30,94

Item 17	% (korr.)
Zahl '8'	32,22
Wurm / Schlange	17,15
Unendlich-Zeichen	5,44
Summe	**54,81**
	% (unkorr.)
nichts o. unkenntlich	14,03

Item 13	% (korr.)
Vogel (im Flug)	31,25
Narrenkappe / Kasper	15,38
Muster/Ornament/Wappen	11,54
Palme	5,29
Summe	**32,21**
	% (unkorr.)
nichts o. unkenntlich	25,18

Item 18	% (korr.)
Kopf (Kasper, Comic,...)	52,58
Baum	12,89
Kaktus	7,22
Summe	**72,69**
	% (unkorr.)
nichts o. unkenntlich	30,22

Durchschnittlich nicht bearbeitet o. unkenntlich:	**20,19**
Durchschnittlicher Anteil von Antworten, die häufiger als 5% sind:	**63,07**

% (korr.): Prozentuale Anteile an den erkennbaren Antworten von bearbeiteten Items

7. Eidesstattliche Erklärung (Affidavit)

Hiermit versichere ich, dass ich diese Arbeit selbständig verfasst und ausschließlich die angegebenen Quellen und Hilfsmitteln benutzt sowie Zitate kenntlich gemacht habe.

Lars Penke
Bielefeld, den 14. November 2003