

MEASUREMENT OF INTELLIGENCE AND PERSONALITY WITHIN THE CATTELLIAN PSYCHOMETRIC MODEL

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ABSTRACT

Cattellian research has been prodigious in systematically investigating the structure of personality traits alongside important cognitive/ability dimensions. Source traits delineated factor analytically in both intrapersonal psychological domains have been incorporated into multidimensional measurement instruments such as the Sixteen Personality Factor Questionnaire (16PF), Clinical Analysis Questionnaire (CAQ), Objective-Analytic (O-A) Battery, Culture Fair Intelligence Tests (CFIT), and Comprehensive Ability Battery (CAB). Several downward extensions of these instruments have been developed such as the High School Personality Questionnaire (HSPQ), Children's Personality Questionnaire (CPQ), and Early School Personality Questionnaire (ESPQ). Boyle (1983) has shown under non-emotive conditions that intellectual abilities tend to overshadow personality traits, in cognitive information processing. Nevertheless, under stressful emotional conditions, involvement of personality traits is enhanced such that cognitive factors may play only a minor role in influencing performance outcomes. The Cattellian psychometric model is one of the few approaches which attempts to index intelligence along with temperament. The present paper provides an overview of the Cattellian integration of intelligence and personality measurement, and discusses some of its benefits and problems.

INTRODUCTION

Relationships between cognitive ability factors and personality traits (as measured in the Sixteen Personality Factor Questionnaire or 16PF — Cattell, Eber & Tatsuoka, 1970; and in the Clinical Analysis Questionnaire or CAQ — Cattell & Sells, 1974; Krug, 1980) have been reported by Cattell (1971), Cattell and Butcher (1968), and by Cattell and Damarin (1968) — (cf. Boyle, 1987c,d). However, as Hakstian and Cattell (1978), and Kline (1979, 1980) have pointed out, these statistically significant correlations generally give only relative-

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ly small multiple correlations, thereby making it difficult to justify the routine interpretation of personality characteristics from cognitive ability measures such as the Culture Fair Intelligence Tests (CFIT — Cattell & Cattell, 1977), or the Comprehensive Ability Battery (Hakstian & Cattell, 1982). Nonetheless, such correlations do throw some light on the nature of the interactions between cognitive abilities and personality traits (cf. Cattell, 1971). As Cattell (1987) pointed out, possible interactions include (1) abilities affecting personality growth; (2) personality affecting ability growth; (3) ability modifying personality expression; (4) personality affecting ability performance (Cattell, 1987). While ability and personality factors are largely independent (cf. Boyle, 1988b; Boyle, Stanley, & Start, 1985, who found relatively moderate overlap/redundancy across modalities), there are nevertheless, some discernible interrelationships (cf. Brody & Brody, 1976; Cattell, 1971, 1982; Eysenck, 1984; Stankov, 1983).

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Generally, the sophistication with which cognitive abilities and personality traits (both normal and abnormal) are measured, differs considerably. Ability factors (cf. Horn, 1977, 1988) are usually measured by objective tests (T-data), whereas personality characteristics (traits) are measured predominantly by questionnaire (Q-data) or rating scales (L-data) — (cf. Cattell & Kline, 1977; Kline, 1986). Self-report and rating data are prone to numerous response sets and distortion ranging all the way from inadequate self-insight to deliberate dissimulation (either faking good or faking bad, depending on the context in which the measurement takes place — Boyle, 1985).

Early work on intelligence-personality intersections was undertaken by Hakstian and Cattell (1978) — (a detailed review of Cattell's model of intellectual structure was provided by Brody & Brody, 1976). In regard to the Cattell-Horn g_f - g_c theory (fluid vs. crystallized intelligence), support for the Cattellian higher-order abilities model has come from factor analytic investigations demonstrating the importance of g_f and g_c in addition to other cognitive factors such as g_m (memory capacity), g_{ps} (perceptual speed), g_r (retrieval capacity), g_v (visualization capacity), and g_a (auditory organization) — (Boyle, 1988a; Stankov, 1983). As Brody and Brody pointed out, a number of implications of this model are apparent: (1) g_f is more influenced by genetic endowment than g_c ; (2) environmental influences on physical development primarily influence g_f ; (3) cultural and education opportunities have their greatest impact on g_c rather than on g_f ; (4) measures of g_f decline at a younger age than g_c measures; (5) brain injury has differential effects on g_f and g_c throughout the course of lifespan development. This well documented g_f - g_c distinction is measured via the Cattellian Culture Fair Intelligence Tests or CFIT — Cattell & Cattell, 1977), which focus primarily on g_f , and the Comprehensive Ability Battery or CAB — Hakstian & Cattell, 1982), which comprises measures of 20 primary abilities, some of which focus predominantly on g_f , while others focus mainly on g_c .

In a study of the inter-battery correlations of the 20 CAB ability tests measuring g_f and g_c , and the 14 scales of the High School Personality Questionnaire or HSPQ — a downward extension of the 16PF — (Cattell, Cattell, & Johns, 1984), no fewer than 50 out of the total 280 correlations were statistically significant. At

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the 5% level of significance, only 14 of these correlation coefficients would have been expected to be significant by chance alone (Keppel, 1991). Although the ability modality is conceptually distinct from the personality domain (Boyle, 1988b), verbal, mathematical, and artistic performances tend to be associated with certain personality traits (Cattell, 1987). What are often thought of as different qualities of ability are probably complex combinations of cognitive abilities and personality traits. Studies with the 16PF and HSPQ have shown a significant increase in prediction of performance, over prediction based on intelligence tests alone (e.g., Boyle, 1983; Boyle, Start, & Hall, 1989; Cattell, Barton, & Dielman, 1972). Cattell (1987, p. 480) reported an average increase of 42 percent in predictive variance by including personality test scores in addition to measures of cognitive abilities, and an average 41 percent increase by including ability measures over and above personality measures alone.

PSYCHOMETRIC MODEL

In Cattellian theory (see Cattell & Kline, 1977; and Kline, 1980, for a detailed review of Cattell's psychometric model), the contribution of personality traits (T), along with abilities (A), motivational dynamic factors (D), and transitory mood states (S) is highlighted in the behavioral specification equation (Equation 1), wherein a represents the behavioral outcome of response or performance j , for individual i , in relation to focal stimulus h , and ambient situation k . The b 's represent the behavioral indices (factor pattern loadings). Thus, behavior is a complex function of the interactions of several intrapersonal and situational variables. Each intrapersonal modality interacts with each of the others in producing behavioral outcomes. In regard to the first-order interaction of personality traits and cognitive abilities, the corresponding multiplicative term is shown in (2) below.

$$a_{hijk} = \sum b_{hjkw} A_{wi} + \sum b_{hjkw} T_{xi} + \sum b_{hjkd} D_{yi} + \sum b_{hjkms} S_{mi} \text{-----} (1)$$

$$\sum \sum b_{hjkwx} A_{wi} T_{xi} \text{-----} (2)$$

Furthermore, there are higher-order interactions as well as the possibility of nonlinear interactions, which must be considered, making the final behavioral outcome a function of numerous such interactions. Also, Cattell (1987) has included "modulation indices" into the behavioral specification/prediction equation. These modulation terms relate to the situational modulation of source traits with respect to each intrapersonal modality (A's, T's, D's, and S's), respectively, given that there is ample evidence of significant interactions between cognitive abilities and personality traits (Boyle, 1990).

With regard to the applicability of the general linear model (GLM) on which virtually all psychometric research to-date, including the Cattellian and Eysenckian models, have been prefaced, it is important to recognize that the GLM encompasses a wide diversity of models, over and above the more limited linear-additive model. Draper and Smith (1981) have made a useful distinction between (1) intrinsically linear models, which can be expressed by suitable transformation of variables, in the standard linear model form (e.g., dummy variables, polynomi-

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als of higher order, reciprocal and logarithmic transformations — Ch. 5), and (2) intrinsically nonlinear models, which are more complex and may have more than one minimum in the parameter space (Ch. 10). Clearly, it would be desirable for psychometric researchers to place more reliance on intrinsically linear models (and perhaps also intrinsically nonlinear models) in addition to the simple, linear-additive model, *per se*.

The Cattellian school has recognized the need for complex psychometric models, as evidenced in the more elaborate versions of the behavioral specification equation (cf. Cattell, 1979/80). Nevertheless, a caveat would seem in order. Suppose that a researcher starts with five predictor variables. Use of squared terms would add five additional predictors, and use of product terms would add at least 10 more, giving a total 25 predictor variables. Capitalization on chance would be quite likely under these circumstances. Consequently, psychometric researchers should be encouraged to report squared multiple correlations (SMCs) adjusted for shrinkage (Pedhazur, 1982, p. 148) in addition to the unadjusted values when they use these more complex models.

MULTIDIMENSIONAL INSTRUMENTS

Many contemporary multidimensional personality instruments are based on theoretical postulation as to both number and nature of the major trait dimensions (e.g., the Minnesota Multiphasic Personality Inventory or MMPI-2; California Psychological inventory or CPI; Hogan Personality Inventory or HPI). The Cattellian school has attempted to overcome this limitation by structuring the 16PF via extensive factor analyses (cf. Cattell, 1978; Gorsuch, 1983) on as comprehensive a sampling as possible of the *normal* personality trait domain (extended into the *abnormal* trait domain with the CAQ).

Studies of physical plasmods with known dimensionality have verified the utility of factor analysis for empirically delineating dimensions (e.g., Cattell & Dickman, 1962). Nevertheless, merely having “factor-pure” trait dimensions (as purported for the 16PF, HSPQ, CAQ, CFIT, CAB, etc.) does not necessarily ensure greater accuracy in prediction. Inclusion of scale scores into a multiple regression prediction equation (regardless of whether or not they represent pure source trait factors) adds significantly to prediction of a criterion (Pedhazur, 1982). In fact, Eysenck (1984) pointed out that the non-factor-pure personality instruments such as the CPI may be as predictive of performance outcomes as are factor-analytically based instruments. However, as Eysenck (1985) also suggested, it would make sense *conceptually* to intercorrelate the CPI items and to undertake a factor analysis of the resulting intercorrelation matrix (preferably on item parcels, given the unreliability of items) in order to produce factor analytically valid trait scales instead of the “folk concept” scales currently used. This is an important point which also applies with equal force to many other non-factored personality instruments. The resulting greater conceptual clarity should enable better testing of psychological theories. Hence, factored scales are to be preferred over non-factored scales, especially in the clinical psychology area, where extreme scores on source trait factors may have etiological, diagnostic, and/or therapeutic implications.

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INTERACTION OF ABILITIES AND PERSONALITY IN ACADEMIC ACHIEVEMENT

Traditional concepts of under- and over-achievement (cf. Gaudry & Spielberger, 1971) are premised on the assumption that it is feasible to predict academic performance from intelligence test scores alone. However, both normal and abnormal personality traits also play a discernible role in modifying learning outcomes. The interaction of personality traits and cognitive abilities is more important in influencing performance outcomes, than is either the effect of abilities or personality traits alone (Cattell & Butcher, 1968). Indeed, the early work by Eysenck (e.g., Eysenck & Cookson, 1969), as well as similar work by Entwistle and Cunningham (1968) demonstrated clearly that the two major personality-type dimensions labelled Extraversion-Introversion, and Neuroticism-Stability (i.e., the first two of the Cattellian second-stratum 16PF factors, as demonstrated unequivocally in factor analyses of the 16PF scale intercorrelations on over 17,000 subjects by Krug & Johns, 1986), play a very important role in influencing performance outcomes, over and above cognitive ability alone. From Eysenckian theory (e.g., Eysenck, 1981, 1983; Eysenck & Eysenck, 1984), it is evident that introverted individuals are conditioned more rapidly than extraverts, and it seems likely that decay of conditioned behaviors is slower for introverts than for extraverts. Studies have shown that at primary school level, stable extraverts tend to perform better than introverts, whereas in senior secondary and tertiary educational levels, stable introverts (and neurotic introverts) tend to outperform extraverts (as reviewed in Boyle, 1984). Thus, successful university students tend to be somewhat more neurotic and introverted than are lower achievers. Presumably, at primary school level, the more verbal, outgoing students are perceived by their teachers as more involved and competent in their work (Eysenck & Cookson, 1969). However, at tertiary educational levels, the introverted students who involve themselves in private reading and study tend to do appreciably better than the more socially oriented and extraverted students, who may find the isolation required for successful study difficult to handle.

There is also an important interaction between ability, personality (anxiety), and performance. Gaudry and Spielberger (1971) have examined this interaction effect and have concluded that while anxiety (neuroticism) may have a debilitating influence on academic performance for students who are intellectually weaker, it is also apparent that for intellectually brighter students, anxiety may serve as a drive to enhance performance. Consequently, examinations (as opposed to written take-home assignments) tend to produce a wider range of scores, separating the brighter and/or more informed students from the duller and/or less well informed students. Therefore, the usual connotation that "test anxiety" interferes with a student's performance level, is only partly true.

Academic learning is best predicted from a combination of ability, personality, motivation, and mood-state measures as shown by Cattell et al. (1972), and Dielman, Barton, and Cattell (1971, 1973). According to Gillis and Lee (1978, p. 241), ability and non-ability intrapersonal variables (motivation, personality, mood states) can account for up to 60 percent of the achievement variation (Cattell & Child, 1975, p. 202; Cattell & Kline, 1977). Yet, this increase may be of little consequence if correlations between personality factors and academic per-

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formance criteria are low (0.3 or less). This apparent low level of association between personality and performance criteria is obtained under non-emotive conditions. Studies of cognitive abilities and personality in relation to academic learning typically do not manipulate emotional state levels, leaving doubt as to the actual relationships pertaining under emotionally aroused or stressful conditions.

Boyle (1983, 1987b) demonstrated that under heightened emotional intensity, correlations between trait variables and performance criteria are enhanced. Boyle (1983) investigated the effects of emotionally disturbing stimuli on academic learning performance. A brief film portraying documentary footage of automobile accident victims, and a post-mortem was presented to a group of 69 subjects, while another 66 subjects served as non-treatment controls. The two groups were matched well across a large number of independent variables. While the emotionally disturbing film produced a learning decrement, it also brought about a 36 percent increase in predictive variance associated with enhanced correlations between the non-ability intrapersonal variables and performance, on a prose learning task.

Boyle (1983) reported that whereas only *one* 16PF scale (Q_2 or Self-Sufficiency) correlated significantly (.25) with academic learning, under neutral emotional conditions, no fewer than *seven* of the 16PF factors correlated significantly with performance under heightened emotional conditions (see Table 1). These results demonstrate the additional contribution of personality traits over and above cognitive abilities to performance outcomes (Kline, 1988). Factor B, measured in the 16PF and CAQ instruments, is a short power measure of general ability. Indeed, whereas intelligence as measured by the ACER-AL (a test of general cognitive reasoning with a verbal emphasis) correlated .35 with performance in the non-treatment group (Boyle, 1983), it correlated only .21 with the criterion in the treatment group. Hence, personality traits may predominate over cognitive abilities in influencing academic performance under emotionally aroused conditions.

Even under non-emotive conditions, significant ability-personality relationships pertain. Hakstian and Cattell (1978) reported a three-factor solution based on their inter-battery factor analysis of ability and personality variables. Factor 1 (Academic Achievement) exhibited significant loadings on Verbal Ability (.50), Speed of Closure (.33), Associative Memory (.40), Meaningful Memory (.33), Spelling (.34), Aiming (.41), Crystallized Intelligence (.60), and on HSPQ traits: G or Superego (.40), I or Sensitivity (.33), O or Insecurity (-.30), Q_2 or Self-Sufficiency (.39), Q_3 or Self-Sentiment (.31), and Q_4 or Ergic Tension (-.30). Factor 2 (Extraversion) loaded on Flexibility (.36), Ideational Fluency (.63), Word Fluency (.34), and Originality (.28), and on traits: A or Warmth (.54), F or Enthusiasm (.49), and I or Sensitivity (.32). Factor 3 (Tough Poise) loaded on Numerical Ability (.45), Spatial Ability (.39), Perceptual Speed and Accuracy (.39), and Mechanical Ability (.31), and on traits: D or Excitability (-.30), E or Dominance (.32), H or Adventurousness (.32), I or Sensitivity (-.46), and J or Individualism (-.55). Evidently, moderate positive correlations exist between cognitive abilities and personality traits of conscientiousness, consideration, and self-control.

Cognitive ability as measured by Factor B is the second largest of the 16PF primary factors. Aside from Factor A, it accounts for the greatest proportion of

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variance among the 16PF factors. Factor B differentiates individuals in terms of "mental capacity" on the concrete-abstract reasoning continuum (Smith, 1988). It involves recognition of analogies, similarities, and classification ability (Birkett-Cattell, 1989), and consists of verbal and numerical items, using easily understood vocabulary and familiar contexts, including both crystallized and fluid intelligence items (Boyle, 1986, 1987b, 1988a). To meet the minimum number of items needed to measure intelligence reliably on Factor B, at least *four* forms of the 16PF (Forms A, B, C, D) should be administered conjointly. This combined administration should give a measure of intelligence comparable to that of major IQ tests. Often however, only Form A (comprising 13 items on B) is administered, which provides less than satisfactory reliability. Even so, a high score on Factor B on a single form is suggestive of high cognitive ability. According to Karson and O'Dell (1976), Factor B is important in interpreting Factor E (Dominance). Usually, high scores on B are associated with high scores on E, and *vice versa*. Yet, it is possible that an individual with a low E score could obtain a high B score.

According to Cattell (1987), frontal lobe impairment diminishes associational, relation-perceiving powers in the emotional control and impulse deferment-inhibition processes. This "frontal-lobe" projection of intelligence into personality characteristics, may partly suggest how intelligence modifies personality. Eysenck (1981) has shown that at extremes of the I.Q. range, psychological maladjustment is more likely. Extremes in intelligence inevitably result in frustrations — deprivation of interpersonal social life (lack of peers on a similar intellectual footing), as well as regression toward the biosocial mean.

Surgent/exuberant (F Factor) individuals seem more able to express intelligence with cleverness and a "sparkling wit" rather than with wisdom (Cattell, 1987). The desurgent/lethargic individual (low F) may be more dependable than "clever," and more prudent. In military recruits, verbal ability has been found to correlate -.25 with Warmth, A, -.35 with Exuberance (F), and -.35 with Sensitivity (I). The negative correlation between intelligence and extraversion (as measured in A and F) may be due the extravert talking more, but reading less (Cattell, 1987; Eysenck, 1983).

RESEARCH FINDINGS WITH O-A BATTERY

Ability-personality interactions are shown most clearly using objective test measures such as the Objective-Analytic (O-A) Battery (Cattell & Schuerger, 1978; Schuerger, 1986). Correlations with certain O-A variables accord with expectations since actual tests put more demands on cognitive functioning, than do simple self-report questionnaires. Personality factors measured via O-A Battery subtests (each factor labelled with a *Universal Index* or U.I. number), exhibit discernible interactions with cognitive abilities. Schuerger (p. 280) reported several correlations between U.I. factors and 16PF Factor B, and with the Lorge-Thorndike (L-T) IQ test scores (see Table 1).

U.I. 19 (Independence) influences performance on both the Gottschalk figures (simple perceptual figures concealed in more complex figures), and on the Witkin field dependence/independence tasks including the Embedded Figures Test or EFT (which correlates 0.3 to 0.6 with field independence). Personality variables

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correlating with field independence include curiosity, social autonomy, and body concept (Horn, 1977). Cattell (1987) maintained that performance on perceptual tasks is a function of U.I. 19. According to Cattell & Schuerger (1978, p. 28), U.I. 19 correlates positively with 16PF primaries Dominance (E+), Suspiciousness (L+), Imaginativeness (M+), Radicalism (Q₁+), and Self-Sufficiency (Q₂+), and the 16PF second-stratum *Independence* factor (cf. Krug & Johns, 1986). Witkin's perceptual behaviors may be expressions of this factor.

TABLE 1

Correlations Between Personality Factors and Cognitive Ability Measures¹

<u>16PF Primary Factor</u>	<u>Ability Measure</u>	
E (Dominance)	-.29 to .20	
G (Superego)	.27 to .30	
M (Imaginative)	.20	
N (Shrewdness)	.26	
O (Guilt Proneness)	-.25	
Q1 (Radcalism)	-.20 to .28	
Q2 (Self-Sufficiency)	.25	
Q3 (Self-Sentiment)	.39	
<u>O-A Battery Factor</u>	<u>16PF Factor B</u>	<u>Lorge-Thorndike</u>
U.I. 16 (Ego Standards)	.21	.48
U.I. 19 (Independence)	.46	.60
U.I. 23 (Mobilization vs. Regression)	.48	.59
U.I. 24 (Anxiety/Neuroticism)		-.24
U.I. 25 (Realism vs. Psychoticism)	.24	.34
U.I. 28 (Lack of Self-Assurance)	-.38	-.45

¹ Summarized from Boyle (1983), Cattell (1987, p. 452), and Schuerger (1986, p. 280).

U.I. 21 (Exuberance) is associated with word fluency and speed of judgement. According to Cattell and Schuerger (1978, p. 29), manifestations of U.I. 21 include high spontaneity, fluency, imaginativeness, speed of social/perceptual judgment, fast tempo (less accuracy than speed). In Q-data it is related to Exuberance (F+), Ergic Tension (Q₄+), Guilt Proneness (O+), and Imaginativeness (M+), and in L-data, to ratings of energetic, forceful and excitable behavior.

U.I. 23 (Capacity to Mobilize vs. Regression) corresponds to the Eysenckian *Neuroticism* dimension. U.I. 23 has been associated with cognitive tasks, includ-

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ing coding exercises, short-term memory and visuospatial abilities (Cattell, 1987). Cattell and Schuerger (1978, p. 30) maintained that U.I. 23 measures general competence, flexibility, emotional balance, and stress endurance. U.I. 23 has some qualities of psychoanalytic regression, showing a decline of interest, and capacity to organize one's thoughts, and is low in psychotic individuals, pointing to disorganization.

Finally, U.I. 17 (General Inhibition) exhibits associations with perceptual slowness, narrowed peripheral visual span, and slowed dark adaptation. According to Cattell (1982, p.364), U.I. 17 involves slower speed of gestalt closure, greater GSR reactivity/sensitivity, avoidance of conflict, low ratio of inaccuracy to motor speed, slowing of response speed with increased complexity, reduced exploration when threatened, and general proneness to inhibition. The tendency of some individuals to "underperceive" could be associated with this factor. Hence, "low perceptual ability" may sometimes result from personality characteristics rather than from cognitive deficiencies.

CONCLUSIONS

In conclusion, research within the Cattellian psychometric school reveals substantial empirical evidence that personality traits and cognitive abilities exhibit appreciable interaction effects. These findings are most pronounced in the area of objective (T-data) measurement of cognitive abilities and personality traits. Future personality test development will most likely place much greater emphasis on T-data measures of personality traits than currently is the practice (because of the obvious difficulties and high probability of response distortion associated with transparent Q-data items). Hence, it is likely that the nature and extent of ability-personality interactions will be clarified and elaborated extensively.

As Kline (1988) pointed out, while there is general agreement on the major ability factors, no similar consensus has been reached with regard to the number and nature of the major personality trait dimensions. The factor analytic structure of personality dimensions remains controversial, particularly at the Cattellian primary factor level. There is much more agreement at the Eysenckian typological level of analysis, where the five Cattellian second-order 16PF factors (cf. Krug & Johns, 1986) correspond directly with Eysenck's type factors (see Boyle, 1989, regarding the "Big Five" personality trait dimensions). The present paper reports numerous correlations between ability factors and Cattellian primary factors, showing that these two domains interact appreciably. Kline (p. 55) concluded that quantification of personality by means of factor analysis cannot capture the full richness of human personality. Even so, further research into the nature of the interrelationships between cognitive abilities and the highly reliable second-order 16PF dimensions may yield some important new insights.

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