

SUBJECTIVE DRUG EFFECTS: A FACTORIAL REPRESENTATION
OF SUBJECTIVE DRUG EFFECTS ON THE ADDICTION
RESEARCH CENTER INVENTORYCHARLES A. HAERTZEN, Ph.D.¹

INTRODUCTION

A large portion of psychological research is addressed to the study of individual differences in psychological test performance. With increasing research on the psychological effects of drugs, it is important to ask whether naturally occurring responses of selected subjects to questions about subjective experiences are related to drug responses. Another question concerns the relationship of differences between certain criterion groups such as normal and schizophrenic subjects and differences in responses of subjects tested under no-drug and LSD conditions (11). These may be regarded as similar if a common factor can be found to account for responses to questions, and for differences between criterion groups as well as between drugs. The similarity between a factor that accounts for responses to questions (an individual difference factor) and a factor which differentiates criterion groups may be made clearer by considering, for example, the factor of intelligence. In this case it would be expected that some relationship would exist between the relative difference in the probability of intelligence test questions being answered correctly by groups rated as geniuses and groups rated as morons, and the probability of correct answers from groups rated high on some intelligence test versus those rated low. That is, the group rated as geniuses or high on intelligence test scores would be

more likely to answer intelligence test questions correctly than those rated as morons or low on intelligence test scores.

An analogous question concerns similarity between an index for criterion group differences, individual differences and drug effects. The wide use of terms such as "psychotomimetic" suggests that certain drugs produce reactions that are similar to certain clinically known symptomatology. Similarity between individual differences and drug effects suggests that presence of a drug underscores certain characteristics which already exist under a no-drug condition. The theory that some drugs underscore certain characteristics is common and is even found in the lay literature: O. Henry was quoted as saying that some people are "half drunk when they are sober" (6). Greenberg (6) elaborated on the meaning of this description of the actions of alcohol: "The individual's temperament plays a large part in his behavior reactions. A few drinks may make a phlegmatic individual normal, a normal person the life of a party, and a vivacious person a nuisance. The end result depends on the starting point." For each conception of this form, however, another can be cited in which a drug appears to oppose the experience or the condition observed and is the basis, therefore, for certain forms of therapy. Thus, opiates are presumed to reduce anxiety. A notion frequently mentioned in the older literature (2, 17), and occasionally still today, is that emotion or experience produced by adrenalin is a "cold experience," an experience with an "as if" quality. But even in some of these descriptive accounts it is clear, at least in some subjects, that adrenalin magnifies ongoing

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¹ National Institute of Mental Health Addiction Research Center, Lexington, Kentucky. Portions of this paper were presented at the Kentucky Psychological Association, Lexington, Kentucky, May, 1963. Copies of the Addiction Research Center Inventory can be obtained from the NIMH Addiction Research Center, P.H.S., Lexington, Kentucky.

experience (as worry). The earlier experiments usually dealt with only one specific drug, and did not integrate subjective experience produced by several drugs.

The present investigation attempts to integrate some subjective effects of eight drugs through examination of drug effects on two individual difference factors that were established by a factor analysis of responses of subjects tested under LSD-25. In this study factor analysis is a method of quantifying similarities between responses to questions that were specially devised to measure the subjective effects of drugs through reference to dimensions that are independent of each other. A dimension is defined as a factor that distinguishes between individuals. The definition of the dimensions will be made clearer in the course of the discussion. Through factor analysis each question can be defined in part by the extent to which responses to it are correlated with a factor. This is the index of individual differences, which indicates whether a factor distinguishes individuals on each question. Drug effects can then be determined on those items which are highly correlated with a factor. Interest here in particular is focused on the question of whether drug effects are evident on items with high factor loadings.

SUBJECTS AND DRUGS

One hundred post-addict Ss were used in a factor analysis of responses to ARCI (Addiction Research Center Inventory) questions for the LSD condition. These Ss, described in detail elsewhere (8, 15), were given concurrently 1.5 mcg/kg of LSD-25 orally and placebo intramuscularly. All Ss were given standard ARCI instructions, which emphasize that questions be answered in the way that S feels "today" (15).

The ARCI was given Ss under no-drug, placebo (oral and intramuscular, IM), pentobarbital (200 mg, IM), chlorpromazine (Day 1, 25 mg, q.i.d.; Day 2, 50 mg, q.i.d.; Day 3, 75 mg, one time only, oral), LSD-25 (1.0 or 1.5 mcg/kg, oral), amphetamine

(30 mg, IM), pyrahexyl (60 or 90 mg, oral) in randomized order. Eighty Ss were given morphine (20 mg, IM) and 50 Ss were given alcohol (3.0 cc/kg of 30 per cent alcohol). Eighteen Ss were given scopolamine hydrobromide (5.0 and 7.5 mcg/kg, IM). Further details are presented by Hill, *et al.* (15).

MATERIALS AND METHODS

The Addiction Research Center Inventory (ARCI) used in this study was especially devised to measure subjective effects of drugs (13). Empiric scales developed earlier for morphine, pentobarbital, chlorpromazine, alcohol, amphetamine, pyrahexyl and LSD held up under cross-validation (15) to a high degree. A "carelessness" index was used to detect and eliminate illiterate, confused or careless Ss (12). Those who obtained a carelessness score of two or more standard deviations above the mean were not used.

Responses to all 550 items of the ARCI were factor analyzed for 100 Ss in the LSD condition (1.5 mcg/kg) by the multiple group method (4), using markers established through smaller analyses (8) and with University of Kentucky IBM equipment.² Ten factors were extracted, but only the first two that reflect drug effects will be described in detail here. Scales were developed for each factor, each generally consisting of 60 items with the highest factor loadings. Retest reliability of the scales was established for 77 individuals for a no-drug and placebo condition (not included as controls for the LSD factor analysis). Other analyses will be mentioned briefly under Results.

RESULTS AND DISCUSSION

As mentioned previously, factor analysis is a method of representing the relationship between responses to questions and factors

² Dr. S. Navarro, Director of the University of Kentucky Computing Center, developed the program for determining tetrachoric correlations for large matrices and Mr. S. Zerof developed subroutines which were used in the multiple group factor analysis.

that distinguish between Ss. In one method the factors are made independent. When this is done, the axes representing the factors are placed at right angles to each other. Any question can then be represented along two or more axes. For example, question 201, "I feel anxious and upset," is located in a square somewhere between .8 and .9 (decimals are eliminated in Figure 1) along the A axis and between .0 and .1 on the B axis. A high positive factor loading indicates a positive correlation between the factor and the response to that question. Thus, a person who obtains a high score on Factor A is likely to answer Question 201 "true," a person who obtains a low score on Factor A is likely to answer Question 201 "false." However, a high score on Factor B may or may not be related to the answer, "true," to Question 201, because a response to Question 201 is not significantly related to Factor B.

With this discussion in mind it can be seen that Figure 1 shows factor loadings for all 550 items of the ARCI in terms of two dimensions for an LSD condition, that is, the item numbers having factor loadings within the various squares. The actual item content can be found in the test booklet for the ARCI. Figure one also indicates the concentration of items. It can be seen that most items lie within the area bounded by +4 to +9 on the A axis and 0 to +5 on the B axis. Very few items are located in the upper left quadrant and even fewer fall in the lower left quadrant. Figure 2 presents the same sort of information about the saturation of items within sectors (defined by lines leading from the center) and samples actual content within various sectors. The content of items is given only for those that have factor loadings of .4 or greater along a particular rotational axis that is designated by numbers for degrees around the periphery. Thus, typical item content along the Factor A axis suggests symptoms that might be associated with a reaction to stress or anxiety and include a lump in the throat, faster heartbeat, fear,

and difficulty in concentration. Items along this A axis are typically endorsed more frequently by subjects tested under LSD. Although many items, such as the one for "anxiety," are quite specific for LSD, some other items, such as those on difficulty in concentration, lump in the throat, confusion, weakness and the like, are not. In fact, a scale which was developed for items with high Factor A loadings (see Table 1 for item numbers used in each factorial scale) was sensitive to all drugs used in the series, including LSD. Although LSD produced the highest effect, other drugs (morphine, alcohol, pentobarbital) listed around the periphery of Figure 2 followed closely.

Referring again to Figure 2, it will be seen that as rotation continues above the A axis, item content associated with the effects of morphine are sampled. (The interpretation is made because morphine produced the greatest effect on such items.) It is emphasized here that content refers to items with factor loadings of .4 or greater; drug effects can not be shown on all items. Thus, an item such as "like to beat a sucker" (axis 10-20 degrees) is not a drug-sensitive question although it is correlated with those that are. Many items in the morphine and amphetamine sectors on which drug effects were found suggest euphoria (feeling "good, popular," mentioning humor or the urge to joke). Items which are more specific for amphetamine suggest greater energy, wakefulness, better memory and efficiency. Some amphetamine effects are opposite to those associated with LSD, alcohol, pentobarbital, scopolamine and chlorpromazine. Thus, Ss under amphetamine may feel energetic, but Ss under the last four drugs may feel tired, sleepy, sluggish and the like. The figure roughly indicates the similarity of subjective effects of drugs by showing the strength of drug effects on scales using items within sectors or by a factor analysis of loading on Factors A and B and drug placebo differences (9). Thus, the effects of morphine and amphetamine are more similar to each

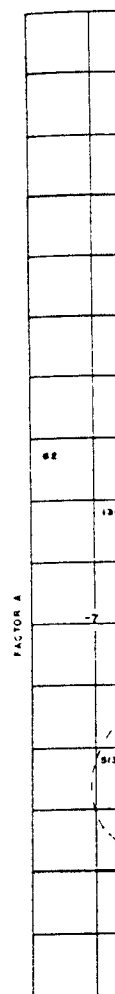


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GROUP FACTOR ANALYSIS: LSD CONDITION

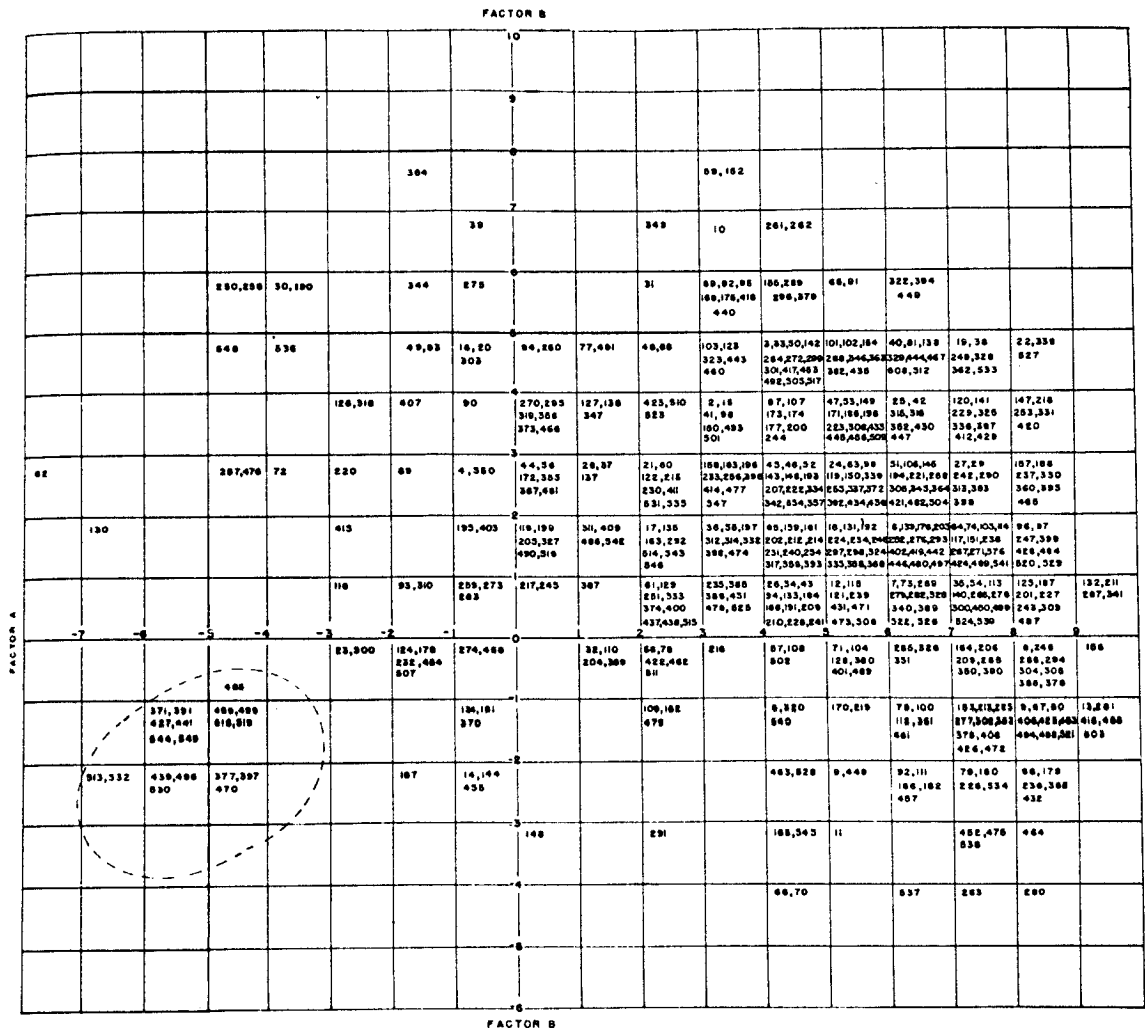


FIG. 1. Group factor analysis of responses to 550 ARCI items for the LSD condition. The abscissa and ordinate refer to loadings for factors A (reactivity), and B (efficiency), respectively. The decimals for factor loadings were eliminated. For example, 1 is the same as .1 and refers to any loading between .1 and .19 but not including .2. The squares similarly define ranges of factor loadings. The factor loading of an item may be within any portion of a square.

The item numbers which are encircled belong in the corresponding position in the upper right-hand quadrant. For example, Item 485 has a factor loading between .4 and .5 on the A axis and between .0 and .1 on the B axis.

other than are those of amphetamine and LSD. The effects of chlorpromazine are somewhat more difficult to locate. Many effects are opposite to those of amphetamine and morphine. It was for this reason that chlorpromazine was placed opposite to morphine and amphetamine. However, there is a greater similarity between chlorpromazine and alcohol and/or pentobar-

bital than appears (9). Hence, chlorpromazine is spread between its indicated location and that of alcohol, and so has a positive effect along Factor A. Some relatively specific effects of alcohol and LSD are not indicated in Figure 2 (9).

The factor along the "A" axis was called "reactivity" and that along B was called "efficiency." The term "reactivity" suggests

change or a reaction expressive of immediate or current experience (as opposed to more enduring and continuing experience). Many subjective states, such as euphoria, anxiety and fatigue, are manifested by common components and also by secondary characteristics. Ss who experience anxiety or euphoria may also report increasing awareness of bodily sensation, excitement and the like. Ss who are tired or anxious may feel weak and have difficulty in concentrating. Ss for a wide variety of reasons may feel specific symptoms such as restlessness which may range from anxiety and increased urge to activity to increased effort to stay awake. Physical symptoms such as "dry mouth" may arise either from anxiety or peripheral physiologic changes. Very few symptoms on close analysis lend themselves to only one interpretation in spite of high factor loadings that presumably suggest a single causal interpretation (3). It is contended here that the reactivity factor or scale is sensitive to a wide variety of different subjective states even though the subjective states may appear opposite in some respects. Many diverse symptoms can be regarded as similar if the symptoms arise as a result of change. Any change in the internal environment, as suggested by Rome and Braceland (19), may constitute a stress. Lange and James (16) recognized some common components in emotion and, more recently, Stevenson (20) presented a number of case histories in which apparently opposite states such as joy and anxiety may have been associated with common symptoms. Insofar as the reactivity factor incorporates a reaction to change, diverse conditions, such as physical and

mental illness or rapid convalescence, subjective drug states, sensory deprivation, may be, in theory, manifested by an increase in score on the reactivity factor or scale.

The second factor, "B," was labeled "efficiency." It covers efficiency in a very broad sense and incorporates contrasting questions such as those concerned with energy versus tiredness, good memory or cognition versus cognitive difficulty or confusion, social effectiveness versus ineffectiveness, emotional control versus lability and active intellectual interests. Amphetamine produces the greatest efficiency in comparison with placebo, and scopolamine increases inefficiency most in comparison with placebo. The effects of these drugs are polar (opposite effect in comparison to placebo) for many items, such as those referring to memory. That is, amphetamine increases a subjective feeling of improved memory more than the placebo condition and scopolamine reduces this feeling.

As suggested, the subjective effects of various drugs can be represented by effects on two factors that were derived from a factor analysis of responses for Ss under an LSD condition. Thus, when a scale is developed on the basis of high factor loadings along the A axis, the drug effect pattern found for the LSD empiric scale (15) can be reproduced. "Pattern" here refers to the mean score produced by drugs in the series on the scale. If an upward rotation is made the pattern produced by the empiric morphine scale can be reproduced. A rotation a bit further will produce the pattern found for the empiric amphetamine scale. If rotation is extended still

FIG. 2. Sample of item content for the reactivity (A) and efficiency (B) factors. The axes for factors A and B were rotated starting from the A axis as indicated by degrees around the periphery. Content was sampled along each rotated axis among items that had factor loadings of .4 or greater on the axis in question. Drug names are indicated on the axis where a drug has its principal unique effect as compared with no-drug and placebo. However, on any one axis drugs can be ordered in terms of the magnitude of difference from the no-drug and placebo conditions. To illustrate, LSD produces the highest effect using questions on the A axis. LSD is followed by morphine, alcohol, pentobarbital, scopolamine, pyrahexyl, chlorpromazine and amphetamine. The ordering of drugs is a function of the dose. Although the average S under placebo is located in the center of the circle, Ss with extremely high scores are not. The performance of such Ss is related somewhat to drug-effect profiles.

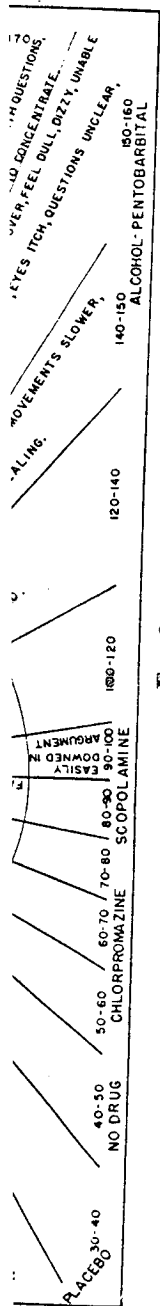


TABLE 1
List of Item Numbers and Direction of Scoring of Factor Analytic Scales

Factor A, Reactivity
<i>True items:</i> 8, 9, 13, 22, 67, 80, 86, 96, 97, 125, 147, 156, 157, 179, 187, 188, 201, 211, 218, 227, 236, 237, 243, 247, 248, 253, 280, 281, 286, 287, 294, 304, 306, 309, 330, 331, 338, 341, 360, 365, 366, 378, 387, 395, 399, 405, 406, 418, 420, 425, 428, 432, 461, 464, 465, 483, 484, 487, 488, 494, 495, 503, 520, 521, 527, 529.
Factor B, Efficiency
<i>True items:</i> 1, 3, 10, 20, 30, 31, 39, 49, 59, 65, 69, 77, 84, 88, 91, 95, 103, 123, 128, 152, 155, 168, 170, 175, 189, 190, 249, 258, 260, 262, 275, 289, 296, 303, 322, 323, 348, 384, 394, 443, 449, 459, 491, 492, 505, 536, 548. <i>False items:</i> 11, 66, 70, 148, 165, 263, 280, 291, 452, 464, 475, 537, 545.
Factor 3, Patience-Impatience
<i>True items:</i> 20, 49, 72, 89, 90, 123, 131, 199, 242, 254, 270, 299, 314, 327, 360, 367, 443, 467, 491, 517. <i>False items:</i> 6, 26, 27, 28, 141, 176, 239, 267, 389, 429, 455, 482, 512, 525.
Factor 4, Sentimental
<i>True items:</i> 21, 42, 61, 62, 69, 104, 110, 131, 134, 146, 148, 161, 183, 186, 207, 216, 228, 230, 273, 274, 318, 319, 333, 350, 365, 369, 374, 413, 437, 451, 475, 493, 501, 507, 508, 511, 515, <i>False items:</i> 4, 22, 55, 124, 142, 151, 172, 178, 203, 205, 223, 255, 278, 288, 300, 349, 359, 395, 444, 447, 453, 454, 503.
Factor 5, Uncritical
<i>True items:</i> 29, 35, 68, 168, 178, 198, 200, 240, 256, 264, 271, 278, 279, 299, 316, 319, 326, 336, 351, 370, 396, 462, 515, 539, 546. <i>False items:</i> 4, 11, 24, 43, 47, 52, 62, 67, 73, 89, 94, 103, 110, 115, 131, 187, 195, 213, 226, 269, 317, 323, 333, 358, 367, 375, 385, 468, 470, 545.
Factor 6, Immaturity
<i>True items:</i> 62, 105, 129, 136, 148, 163, 177, 181, 200, 204, 216, 228, 238, 242, 259, 273, 296, 297, 304, 319, 330, 354, 359, 377, 391, 403, 405, 409, 465, 468, 507, 543, 548. <i>False items:</i> 5, 8, 9, 23, 50, 74, 79, 133, 158, 210, 239, 260, 261, 278, 320, 356, 368, 376, 393, 401, 413, 417, 430, 463, 478, 486, 500, 534, 537.
Factor 7, Masculinity-Femininity
<i>True items:</i> 1, 14, 55, 56, 108, 131, 165, 208, 256, 289, 311, 318, 323, 333, 334, 346, 373, 455, 489, 495, 535, 539, 547. <i>False items:</i> 18, 44, 118, 121, 141, 179, 199, 254, 258, 264, 292, 392, 403, 462, 468, 469, 474, 533.
Factor 8, Inadequacy
<i>True items:</i> 24, 39, 117, 136, 148, 197, 249, 269, 292, 299, 304, 320, 349, 364, 378, 397, 409, 439, 453, 489, 495, 504, 509. <i>False items:</i> 28, 41, 49, 81, 89, 105, 118, 123, 124, 126, 128, 167, 204, 264, 270, 297, 347, 348, 414, 442, 446, 466, 470, 479, 491, 507, 508, 518.
Factor 9, Impulsivity
<i>True items:</i> 26, 40, 50, 51, 102, 107, 119, 140, 148, 159, 162, 173, 174, 184, 192, 193, 194, 206, 218, 289, 298, 301, 316, 324, 333, 335, 337, 339, 354, 368, 371, 391, 394, 400, 441, 474, 485, 498, 516. <i>False items:</i> 7, 23, 24, 67, 89, 128, 178, 179, 237, 242, 297, 402, 413, 512.
Factor 10, Neurotic Sensitivity vs Psychopathic Toughness
<i>True items:</i> 4, 31, 36, 39, 45, 57, 62, 70, 85, 104, 121, 125, 135, 136, 137, 148, 157, 166, 179, 208, 256, 355, 380, 421, 433, 467, 511, 526, 537, 544, 547. <i>False items:</i> 28, 41, 109, 131, 134, 141, 167, 188, 191, 202, 223, 226, 252, 255, 335, 351, 359, 363, 419, 435, 445, 446, 451, 460, 473, 475, 489, 495, 507, 508, 515, 532.

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further to the B axis, a so-called amphetamine-specific pattern is produced (described above in terms of polarity of amphetamine and other drugs, as scopolamine). The drug patterns produced by various empiric scales can also be replicated by combining different fractions of the T-scores or raw scores from Factor A and B for the different drug conditions. That is, a 100 per cent portion of A and a zero portion of B are productive of the drug effect pattern found on the LSD empiric scale. Thus it would seem that the two factor-analytic scales are important indicators of individual differences and drug effects and should be used and accounted for in any pattern analysis of scales with a population of drug addicts. Preliminary work with other groups such as normal and mentally ill Ss indicate that the factors have generality.³ The two scales also have generality in the sense that the correlations between conditions are significant. Correlation between individual differences and drug effects means that some Ss in a drug-free state will produce a pattern of responses like those produced under drug conditions.

Although interest in this paper is centered chiefly on factors for which drug effects can be demonstrated, a short description of the remaining factors will be mentioned. The item numbers and directions of scoring are given in Table 1. T-score transformation tables, mean scores and the like are given in the ARCI Appendix of scales (10).

The *third factor* was called "patience-impatience" and is related to the efficiency factor. Ss who are high on this factor scale feel patient, calm, controlled and self-satisfied, and those who obtain low scores feel irritable, negativistic and stubborn. LSD significantly reduces scores on this

scale. The mean T-score for the high dose of LSD was 41.5. The means of other drugs fall within three points of the mean for no-drug and placebo (the groups on which all ARCI scales were standardized; a mean of 50 and a standard deviation of ten were used for all scales [15]).

The *fourth factor*, "sentimentality," suggests an increase in sentimental feelings and attitudes and includes concern over past relationships, both positive and negative. The means for all drug conditions were within three points of the standardization mean of 50. Ss who have high scores on this scale feel an immediate appetite for alcohol.

The *fifth factor* suggests noncritical attitudes and denial of being the focus of criticism and was labelled "uncritical." It is positively correlated with scales such as K on the MMPI that indicate a tendency to put oneself in a favorable light (14). This factor was not appreciably affected by drugs.

The *sixth factor* was called "immaturity" because it suggests denial of the importance of cultural goals such as marriage. LSD produced a very small decrease in expression of immature attitudes.

Items in the *seventh factor* are suggestive of either masculine or feminine interests. Drug effects are not especially noticeable on it although specific items contained in the scale are sensitive to certain compounds. The scale is related to masculinity-femininity scales of the Guilford-Zimmerman Temperament Survey (7), California Psychological Inventory (5) and MMPI (14).

Many items in the *eighth factor* suggest "inadequacy." Drugs have no appreciable effect on the factor. It is correlated with the schizophrenia scale of the MMPI. The reactivity factor is also correlated positively with the schizophrenia scale and negatively with defensiveness.

The *ninth factor*, called "impulsivity," is related to Guilford-Zimmerman Temperament Survey scale (a measure of re-

³ These results refer to 33 normals tested by Dr. Roy Yamahiro (General Mills, Minneapolis, Minnesota) and over 200 mentally ill individuals tested by Dr. Robert Long and Dr. P. Philip of St. Peter State Hospital, St. Peter, Minnesota.

straint or introversion). No drug effects were apparent on it.

The *tenth factor*, "neurotic sensitivity versus psychopathic toughness," suggests neurotic characteristics and is related to MMPI neurotic scales. The negative pole contains many psychopathic-like items, as taking pleasure in beating a "sucker." It is negatively correlated with a social deviation or delinquency scale that was developed from the psychopathic deviate scale of the MMPI (1, 18), and does not appear to be affected by drugs.

Analysis of the retest reliability of these scales for 77 individuals showed that those who obtain a high score under no-drug will obtain a high score under placebo. Significant correlations across conditions, both between placebo and no-drug and between no-drug and drugs, has particular significance in suggesting that individual differences remain at least partially the same regardless of the condition, and that there will be some similarity between the pattern of scores on scales regardless of whether an S is tested under a drug or not. Since some drug effects are related to individual differences, it means that scales derived from drug studies may prove to be as useful for the understanding of personality as scales derived from comparisons between normal and mentally ill Ss.

SUMMARY

Five hundred fifty questions from the Addiction Research Center Inventory were factor analyzed using the responses of 100 post-addict male Ss who were given 1.5 mcg/kg of LSD-25. Ten factors were extracted but only two of these were substantially related to the effects of eight drugs: LSD, morphine, amphetamine, pentobarbital, chlorpromazine, pyrahexyl, alcohol and scopolamine. All drugs in the series produced significant change on the first factor, reactivity. It is theoretically possible that the factor is general enough to be sensitive to other states, such as

physical or mental illness, that may contain some general reactive component associated with change. The second factor, efficiency, is a polar factor in the sense that some drugs produce effects on it which are opposite to those under placebo. Thus, amphetamine increases the feeling of energy and memory capacity, but other drugs (such as scopolamine) decrease the feeling.

Using these two factors, a general spectrum of similarities and differences among drugs can be demonstrated and serves as an organizing principle for relating subjective drug effects. Thus, the subjective effects of amphetamine are more similar to those of morphine than to those of LSD. The effects of chlorpromazine are more similar to those of alcohol and pentobarbital than to those of amphetamine or morphine. The effects of morphine and amphetamine are opposite to some of the effects of chlorpromazine. Some of the effects of amphetamine are opposite those of alcohol, pentobarbital, LSD, chlorpromazine and scopolamine.

The factor loadings for the first two factors are correlated with the magnitude of certain drug effects. At least part of the pattern of drug effects may be simulated by certain Ss in a nondrug state.

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