Critical Review of State-Trait Curiosity Test Development[1]

Gregory J. Boyle[2]
Institute of Catholic Education, Australia

State-trait research offers good prospects for new insights into human curiosity. It has already generated development of new scales, and several studies have been undertaken independently in Australia and the United States. This paper critically reviews the development of state [C-State] and trait [C-Trait] curiosity scales, pointing out methodological limitations in the existing state-trait curiosity studies. Specific recommendations are made with the aim of enhancing future research in this area.

BACKGROUND THEORY

Many theorists have regarded curiosity as a state (e.g., Hebb, McClelland, Maddi, McReynolds). However, the foremost and most prodigious of these was Berlyne. In numerous investigations, Berlyne (e.g., 1960, 1970, 1971, 1974, 1975, 1976, 1978, to mention a very few of his papers) conceptualized curiosity as a construct intervening between collative stimuli (such as complexity, novelty, incongruity, ambiguity, blurredness, surprisingness, power to induce uncertainty) and exploratory responses. Berlyne based his approach to curiosity on the homeostatic model, accepting Hebb's (e.g., 1972) postulation of an optimal level of physiological arousal, deviations from which tend to be aversive. Berlyne (1974) posited separate reward and aversion systems in the CNS, which are brought into action by different magnitudes of arousal increment, related directly to the arousal potential of

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[2]Address all correspondence to Gregory J. Boyle, Institute of Catholic Education, Oakleigh Campus, 17 Castlebar Road, Oakleigh 3166, Victoria, Australia.

incoming stimuli. According to Berlyne, the relationship of arousal potential to hedonic satisfaction followed Wundt's (1874) summary curve, whereby moderate increases in arousal are rewarding, while extreme increases are aversive. However, this model made no provision for interactions due to different subject reactions to arousal levels in differing contexts and it has been criticized for not quantifying the point at which arousal becomes dysfunctional, with concomitant reduction in learning (Zaritsky, 1976, p. 108).

Berlyne investigated extensively the effects of collative stimulus properties on exploratory and attentional responses in humans (collative stimuli can often be explained in terms of information-theoretic concepts; power to induce uncertainty can be calculated according to the formula $H = -\sum_{i=1}^{n} p_i \log_2 p_i$, as per Berlyne, 1963). However, in most of his experiments, Berlyne utilized two-dimensional visual stimuli to alter the prevailing level of collative variability. Most often his response measure was looking time. Therefore, the emphasis was more on perceptual rather than complicated conceptual stimuli (Robinson, 1974). A neobehaviorist, Berlyne (e.g., 1975) focused on curiosity as a state. He was not unaware of trait aspects (Berlyne, 1966), but he chose not to study them, likely because of the many problems inherent in trait measurement (cf. Patrick, Zuckerman, & Masterson, 1974). Berlyne accepted the cognitive view that much intellectual-emotive activity logically must intervene between stimulus and response, but he attempted to account for it in neobehavioristic terms. According to Berlyne (1975, p. 79), "Several lines of research are beginning to call unmistakably for a multi-level view of learning and behaviour, according to which behaviour-controlling mechanisms of increasing complexity are successively superimposed on one another . . . . And symbolic or cognitive functions are found only at the highest levels."

On a different note, Berlyne restricted his research on humans to attempts to trigger specific curiosity and to satisfy it. He avoided the induction of boredom in his experiments. As a Hullian disciple, he rejected diversive exploration as an unclear motivation state (Berlyne, 1968, p. 189; 1971, p. 190; 1978), denying its relationship to curiosity (this denial was not accepted by subsequent theorists, such as Day or Leherissey, however). Even recent papers (e.g., Naylor, 1981, p. 173) have persisted in mistakenly attributing the notion of diversive curiosity to Berlyne. Berlyne did not investigate the effects of punishing curiosity behaviors but instead emphasized the need to investigate more fundamental research questions first (Berlyne, 1975, p. 74). Berlyne's programmatic research was therefore entirely logical and sequentially planned. Had he lived longer, he would almost certainly have explored such issues as the one pertaining to possible

aversive outcomes of curiosity-induced behaviors. He certainly recognized the need to explore such issues, however.

State curiosity theory subsequent to Berlyne is best exemplified in the work of Robinson (1974). Robinson proposed an elaboration of Berlyne's model wherein all responses were built into a feedback loop, which allowed cognitive appraisal to alter the prevailing level of C-State. Robinson eliminated Berlyne's distinction between perceptual and conceptual conflict, and in their place simply put "uncertainty." This seems strange in view of Berlyne's contention that not all uncertainty produces conceptual conflict (Berlyne, 1960). Moreover, there is evidence for distinguishing between sensory and cognitive types of curiosity (in Pearson's, 1970, Novelty Experiencing Scale [NES], the sensory and cognitive subscales are minimally correlated; also Zuckerman's, e.g., 1971, Sensation Seeking Scale [SSS] relates to both internal and external sensory curiosity, but not to either type of cognitive curiosity). Robinson did differentiate between internal and external stimuli as sources of uncertainty. He also suggested a more flexible structure for Berlyne's epistemic behaviors. Thus, "Reasoning" was regarded as partly observable and partly nonobservable. "Observation" accounted not only for Berlyne's simple inspection but also for the sophisticated empirical observation of scientists. Overt questions were shown to arise from any of the epistemic behaviors, prior to entering the feedback loop. Also, covert questions were shown as originating from either Reasoning or Observation. Yet both Berlyne and Robinson have given descriptive accounts of the curiosity process. In addition, both models failed to explain adequately human curiosity in relation to higher cognitive functioning, despite both having acknowledged its importance.

Allowing for curiosity as a motivational state, Day (1971) moved away from this initial emphasis and chose to focus on curiosity as a relatively enduring personality trait. This extension of Berlyne's work into the trait domain was based on Day's (1965) finding of a stable preference for particular levels of visual complexity over time. Day (1966, 1968), also had observed significant individual differences among subjects on various measures of complexity (including his own test of visual complexity). He regarded trait curiosity as having both specificity and reactivity, as well as chronicity. According to Day (1971, p. 102), "a person can be said to have a trait characteristic to curiosity if he has the propensity for either becoming curious under more conditions (specificity), more readily becoming curious (reactivity), and/or possibly remaining in a state of curiosity for longer periods of time (chronicity)." Not only did Day extend Berlyne's work into the trait domain, but he also refined Berlyne's concept of diversive exploration, extending it to curiosity, in an attempt to integrate more adequately specific and diversive aspects of the curiosity process (Day & Berlyne, 1974, p. 196).

According to Day (1971), diversive curiosity is characterized by heightened arousal, which is induced by changeless, monotonous, repetitive stimuli. Indeed, the very absence of stimuli may induce diversive curiosity and exploration.

In order to measure individual differences in C-Trait, Day constructed the Ontario Test of Intrinsic Motivation (OTIM; cf. Day & Maynes, 1972). Influenced by Guilford's conception of intelligence on the model of a cube (the validity of Guilford's, 1967, model of intellectual structure has been thoroughly disputed — Boyle, 1983a, Brody & Brody, 1976, among others), as well as by Kuder's (1970) work on interest categories, Day (1971) produced a three-dimensional model of C-Trait, each cell of which was assessed by one question only in the OTIM. Clearly, one item per cell would yield unstable responses, lacking in reliability. As Day and Maynes (1972) pointed out, the OTIM, with its 90 specific curiosity items, its 10 diversive curiosity items, and its 10 social desirability items, lacked adequate discriminatory power and failed to correlate significantly (over all 110 items) with various Kuder interest categories.

Day also proposed a one-factor model, relating curiosity and anxiety states to moderate and high arousal, respectively (Day therefore followed on from Berlyne's earlier position, although Berlyne, 1974, proposed a new two-factor model, as mentioned above). Day's one-factor model is inadequate since a person's cognitive appraisal of a low stimulus situation might induce a psychological state of either diversive curiosity or anxiety. In the first case, physiological arousal might increase gradually to a more hedonically satisfying level as a result of diversive exploration in response to the diversive curiosity state (contrary to Day's assertion, e.g., Day & Berlyne, 1974, that diversive curiosity involves heightened arousal levels). In the second instance, the individual might seek to escape from the low stimulus situation in order to reduce the heightened arousal that resulted from the cognitive appraisal of an anxiety state. Zuckerman (1969, 1974, 1976) has reported that heightened levels of anxiety state can arise during sensory deprivation experiments. Hence, the attempt to equate motivational states with arousal levels seems untenable, at least in any simple way. The dilemma is further compounded by the need to distinguish cortical from autonomic arousal. As Zuckerman (1969, 1974) indicated, the two systems are essentially independent. Not only sensory deprivation but even sensory restriction, as in time-out therapy with hyperactive children (Boyle, 1979a), can result in an anxiety state instead of a state of diversive curiosity. Clearly, both the one-factor and two-factor models cannot account for differences in motivational states. Leherissey (1971, 1972) severely criticized both these models due to their marked limitations.

Beswick (1971, 1974; Beswick & Tallmadge, 1971; Beswick & Lakshmana Rao, 1976) denied the simple equation of arousal and

motivational states, postulating a cognitive process theory of C-Trait instead. Unfortunately his theory represented a mixing of general intelligence with curiosity (Berlyne and his colleagues were not unaware that curiosity and intelligence interact, but they considered the delineation of curiosity as a construct to be more important). Beswick contended that one's conceptual system encodes and organizes perceived stimuli, and that individual differences in C-Trait derive from the separate development of openness and orderliness (cf. Freud's two bases for human curiosity — sublimated scotophilia, and an ego coping mechanism; Aronoff, 1962). Individual differences in C-Trait were regarded as a function of both category system attributes and coding differences. Difficulty of coding was assumed to vary both within and between individuals, and to involve a corresponding degree of assimilation and/or accommodation. Beswick regarded the highly curious individual as one who both seeks curiosity-arousing situations and reacts more readily — and with greater intensity — to such situations. He regarded C-State as a fundamentally unstable, superficial entity. Few theorists would agree with this contention (e.g., Zuckerman, 1976, p. 166; Thorne, 1974, 1980).

Beswick constructed a short (16-item) self-report measure of C-Trait, with items derived from sources such as the OTIM, Fitzgerald's (1966) openness-to-experience measure, and Cattell's curiosity erg (e.g., Cattell, 1979, 1980, 1982; Cattell & Child, 1975; Cattell & Dreger, 1977; Cattell & Kline, 1977; Cattell, Horn, Sweney, & Radcliffe, 1964). Beswick (1974; Beswick & Lakshmana Rao, 1976) reported encouraging estimates of validity and reliability, with significant correlations being obtained with interest in various academic subjects among senior secondary school subjects. For Beswick it was not the elimination of conceptual conflict that mattered, but rather the reduction of uncertainty. According to Beswick (1971, pp. 159-160), a person high in C-Trait remains in the situation of conflict, performing acts instrumental to removing uncertainty, but that simultaneously delay resolution of the conflict.

Several other theorists have regarded curiosity primarily as a relatively stable personality trait. Using the NES, Pearson (1970) demonstrated the lack of comprehensive and representative coverage of the novelty domain by the various C-Trait measures in use. Maw and Maw (e.g., 1977), using rating techniques on elementary school children, investigated the relationship of various personality and cognitive factors to C-Trait. Numerous other trait theorists also made significant contributions (e.g., Penney & McCann, 1964; Penney & Reinehr, 1966; Vidler & Rawan, 1974) by constructing scales for measuring different aspects of C-Trait.

More germane to the present state-trait research focus was the work of Leherissey (1971, 1972). According to her (1971, p. 3), "conceptual clarity is gained by the distinction between curiosity as a state and as a trait,

which should hopefully lead to more adequate experimental predictions and procedures." Leherissey developed the State Epistemic Curiosity Scale (SECS), consisting of 20 self-report items (15 direct, and 5 reversed items), which are measured on a 4-point Likert scale. Leherissey based the SECS on the assumption that state epistemic curiosity behaviors depend directly on the individual's desire to "(a) know more about a learning task; (b) approach a novel or unfamiliar learning task; (c) approach a complex or ambiguous learning task; and (d) persist in information-seeking behavior in a learning task" (1971, p. 14).

Preliminary findings suggested that the SECS demonstrated satisfactory reliability and validity (Leherissey, 1971, 1972). Alpha coefficients ranged from .81 to .86, while correlations between pretask and posttask SECS measures and the OTIM were .52 and .37, respectively. Judd, Leherissey-McCombs, and O'Neil (1973) reported similar findings with high internal consistency estimates for the SECS (alphas ranging from .87 to .94), along with moderate negative correlations between SECS and State-Trait Anxiety Inventory scores (STAI; Spielberger, Gorsuch, & Lushene, 1970). Nevertheless, the SECS measured only state epistemic curiosity, and additionally, it measured this particular type of curiosity in a rather narrow fashion, given the high alpha coefficients (see the section on Limitations, below, for a discussion of item homogeneity/redundancy). Leherissey used the OTIM to measure C-Trait, while trait diversive curiosity was indexed via the SSS, together with the OTIM diversive curiosity items. She postulated a three-factor model, wherein the states of anxiety and diversive and specific curiosity were distinct systems. This was definitely an advance over the two-factor model proposed by Spielberger and Butler (1971) and Berlyne (1974), while at the same time being nugatory. Thus, she failed to distinguish between cortical and autonomic arousal, and she totally neglected the role of C-Trait in her model (cf. Leherissey, O'Neil, & Hansen, 1971). Indeed, Leherissey, Berlyne, and Day all failed to avoid the simple equation of motivational states with arousal. These models were somewhat superficial, simply assuming the existence of diversive and specific curiosity states as factual entities. However, triggering of C-State might be dependent largely on cognitive appraisal of stimulus situations (the latter influenced by the individual's C-Trait characteristics). Therefore, it would seem desirable to view human curiosity as a psychological system, in terms of an interactional state-trait model.

On a more fundamental level, Langevin (1971) factor-analyzed many of the curiosity measures then in use, and extracted two main factors, which he labeled breadth of interest and depth of interest. Langevin (p. 369) concluded that breadth curiosity reflects an enduring personality dimension (C-Trait), whereas depth curiosity reflects the intensity of a fluctuating motivational state (C-State). This finding received support in the work of

Ainley (1979, 1983), in a factor analysis (principal components, plus varimax rotation) on over 200 Australian college students, and several measures of curiosity. Langevin (1976) concluded that the multifacted nature of curiosity was an artifact due to inadequacy of the prevailing curiosity measures. Given Langevin's findings, together with the assertions of Leherissey, it seemed logical to construct separate C-State and C-Trait measures to test the validity of the state-trait model of curiosity. Along these lines, Boyle (1977) proposed a simplified conceptual model of state-trait curiosity, using Spielberger's (1966) anxiety model as a prototype. Figure 1 presents Boyle's schematic model. As shown, a temporally ordered sequence of events is implied, such that a stimulus cognitively appraised as curiosity-enhancing evokes a C-State reaction. Moreover, the particular stimuli that are appraised as curiosity-arousing are determined largely by individual differences in C-Trait. These stimuli may be either specific or diversive, although mostly the former.

In regard to dynamic motivational states and nondynamic traits (including curiosity), Cattell (1980, 1982) has proposed an elaborate systems theory model that follows the general principles of systems theory as used in other sciences. Such a model (Cattell, 1980), pp. 431-438) is extremely complex, and while it may ultimately have excellent fecundity for curiosity research, it probably exceeds current practical research limits. Therefore, the more parsimonious state-trait curiosity model proposed by Boyle would seem better suited for stimulating research experiments in the immediate future.

RECENT STATE-TRAIT CURIOSITY STUDIES

A recent application of state-trait curiosity research has been the work of Naylor and Gaudry (1976). They asserted that "C-Trait is built up by exposure to situations which stimulate C-State responses, though the quality of these situations and the outcome of the approach responses may determine the likelihood of C-State being aroused again in a similar situation" (p. 3). Naylor and Gaudry maintain that while no situation necessarily arouses C-State to a similar extent, certain situations are characteristically arousing. They stressed the interactional nature of C-State and C-Trait. By constructing global C-State and C-Trait scales, Naylor and Gaudry not only attempted to avoid the particularities of previous measures (limited to measuring, say, epistemic or perceptual aspects of specific curiosity) but also aimed to simplify curiosity conceptualization in accord with the research suggestions arising from the studies of earlier theorists, such as Berlyne, Day, Beswick, and Leherissey. Several studies using Spielberger's STAI (Spielberger et al., 1970) had been encouraging for the development of similar scales in the curiosity domain (e.g., Gaudry &
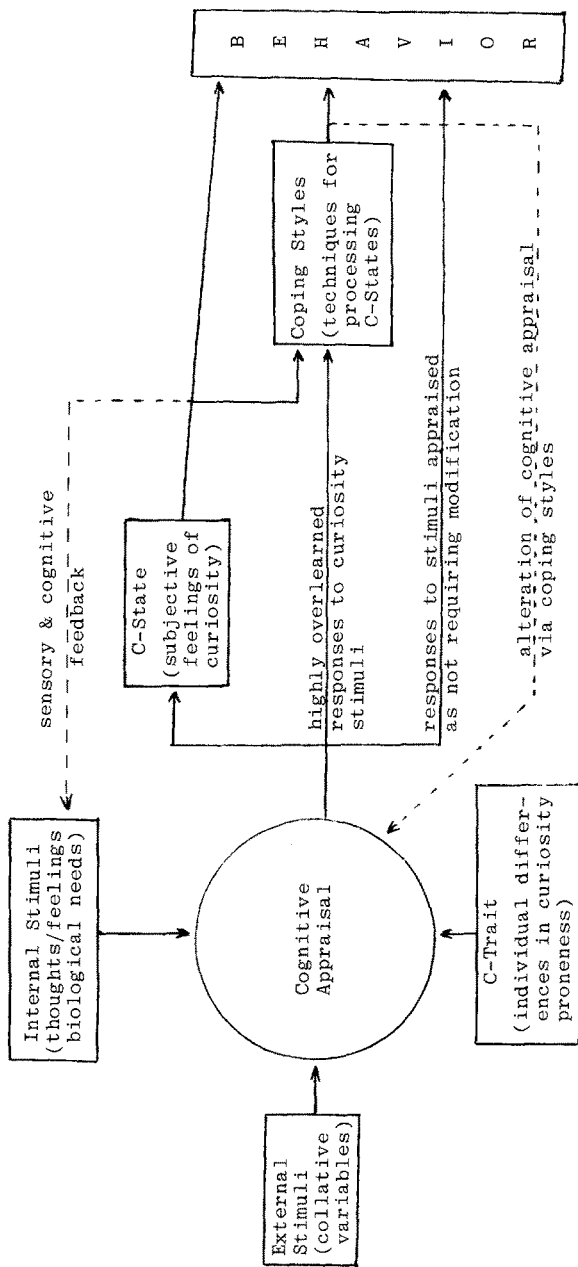
Fig. 1. Conceptual model of state-trait curiosity.

Poole, 1975; Gaudry, Vagg, & Spielberger, 1975; Spielberger, Vagg, Barker, Donham, & Westberry, 1980). Unfortunately, it now appears that the STAI is an invalid measure of state and trait anxiety, particularly in regard to the state (A-State) scale (Naylor, 1978; Naylor, Elsworth, & Astbury, 1980). Even as far back as 1973, Cattell had conducted detailed factor analyses of the STAI along with personality trait and emotional state factors and, adhering strictly to concise factor-analytic guidelines (Cattell, 1973, p. 284), concluded:

> Very provocatively for the Spielberger STAI use, the supposed trait and state measures therein now appeared as *two states* (or conceivably a trait change and a state). Thus the results confirm . . . Spielberger's supposition that the STAI contains two distinct scales but identify them by a majority of markers as being different from anxiety trait and anxiety state. The change on the trait is a solid measure of stress and the supposed anxiety state measure is an equally solid measure of depression. (pp. 211-212)

Nevertheless, given the often reported negative correlation between anxiety and curiosity (cf., for example, Boyle, 1979b; Naylor, 1981), Naylor and Gaudry (1976) used the STAI as a model and constructed 20-item scales of C-State and C-Trait, to which responses could be made in the four categories of almost never, sometimes, often, and almost always for C-Trait, and not at all, somewhat, moderately so, and very much so for C-State. Eleven direct-worded items, and nine reverse-worded items (to reduce the possibility of an acquiescence set) were selected for each scale. An example of a direct C-Trait item was "I feel like asking questions about what is happening," whereas one reversed item was "I feel apathetic about things." For the C-Trait scale, the subject was required to respond as to how he/she *generally* feels. For the C-State scale, the items had identical content, but the subject had to respond as to how he/she felt *at a particular moment in time*. Scoring of the C-State and C-Trait scales was similar to that for the STAI.

The germinal research involved two large sample studies (N = 490 and N = 344, respectively) in which Naylor and Gaudry (1976) administered the Australian Council for Education Research (ACER) Test ML (a verbal measure of general ability), followed by the C-Trait scale and the STAI A-Trait scale, to students in grades 10, 11, and 12 in several Melbourne metropolitan schools. The students were then given a decoding task but were interrupted before completing it. The C-State scale was then administered, followed by the STAI A-State scale. Alpha coefficients ranged from .77 to .88 for the C-State and C-Trait scales. Naylor and Gaudry produced a second-order varimax rotated factor-analytic solution, which supported their state-trait interpretation of curiosity. Factor I (14.73% of the variance) was marked mainly by reversed C-Trait items and

direct A-Trait items. This factor was labeled trait neurasthenia (N-Trait). Factor II (13.11% of the variance) represented direct C-Trait items. Factor III (12.87% of the variance) involved direct and reversed C-State items. Its bipolarity (a few direct A-State items also loaded this factor) suggested the incompatibility of curiosity and anxiety states (cf. Zuckerman's, 1976, two-factor theory of approach and withdrawal, pp. 164-167). Factors IV and V were anxiety factors. Naylor (1979) discussed the desirability for the state-trait distinction in curiosity, and outlined the construction of the C-State and C-Trait scales.

Subsequently, the Melbourne research group undertook numerous additional investigations into the factor-analytic structure of the C-State and C-Trait scales. Several investigators supported the basic findings of Naylor and Gaudry (1976) regarding the psychometric properties of the C-State and C-Trait scales, using a variety of experimental arrangements and samples of secondary and college level students as subjects (e. g., Doig, 1976; Devlin, 1976; Nichols, 1976; Boyle, 1977; Dickie, 1977; Mathews, 1977; Rawlings, 1977; Ainley, 1979, 1983). Given the prodigious amount of empirical research data generated, it is not appropriate to review each of these unpublished studies in depth here. For the sake of brevity, only the principal findings are presented (a critical appraisal of these studies is presented, however, in the next section of this paper). The interested reader can nevertheless pursue these studies in several theses lodged in the University of Melbourne library, in the event that further details are required. What is important from this productive mass of empirical research is that, despite initial developmental difficulties (typically associated with any new scale), state-trait research offers better prospects for significant new insights into human curiosity than had hitherto been possible with the previously existing plethora of specialized scales purporting to measure various aspects of curiosity.

The essential findings over all the above state-trait curiosity studies were as follows: (1) Both the C-State and C-Trait scales exhibited high levels of internal consistency (high item homogeneity/redundancy), as reported by Naylor and Gaudry (1976), Doig (1976), Nichols (1976), and Boyle (1977, 1979b), among others. Alpha coefficients for the C-State scale were consistently higher (about .9) than were those for the C-Trait scale (about .8). In each case, the alpha estimate for the direct curiosity items was higher than that for the reversed items (being .88 and .80 for the C-State scale, and .80 and .64 for the C-Trait direct and reversed items, respectively, in the Naylor and Gaudry studies, for example). (2) While distinct C-State and C-Trait factors have emerged consistently from the various factor analyses, the direct and reversed items have, however, loaded orthogonal factors (summarized in Boyle, 1979b; Naylor, 1981), thereby indicating that the

reversed and direct items measured different constructs. Given the face
validity of the direct items (and face validity says nothing necessarily about
the true validity of a test; Kline, 1979, pp. 8-10), the consensus seemed to be
that the reversed items were not measuring curiosity (see the next section for
a discussion of the transparency of the direct items, however). As reported
by Mathews (1977), the direction of item wording readily influenced not
only C-State and C-Trait scores but also STAI scores, in terms of obtained
means and variances. (3) Some test-retest evidence existed for the greater
stability of the C-Trait scale over the C-State scale, as expected from
state-trait theory (being .77 and .56, respectively, in Boyle's, 1979b, study).

In the published study by Boyle (1979b), the effects of manipulating
C-State levels upon learning performance was investigated. Boyle randomly
assigned 300 secondary school students in grades 10, 11, and 12 to (a)
curiosity-stimulating instructions (CSI), (b) neutral instructions (NI), and
(c) boredom-inducing instructions (BII) groups, respectively. Treatments
preceded the first administration of a test battery (comprising C-State,
SECS, A-State, and C-Trait scales, in that order). A comprehension
passage ensued, followed by a second administration of the test battery.
Finally, a posttest of immediate retention compared each group's learning
performance. In separate factor-analytic approaches (one on items, the other
on subscales), Boyle obtained evidence supportive of the construct validity
of the two scales, with separate C-State and C-Trait factors emerging from
each analysis. In accord with the general findings of the Melbourne research
group, Boyle also reported that the direct and reversed items loaded
separate orthogonal factors, while the corresponding subscales loaded the
opposite poles of a bipolar curiosity factor at the second-order level (see
Boyle, p. 76). In the factor analysis of items, the variance accounted for by
the direct items was 21.2%, as compared with that for the reversed items,
which was 10.6%. Therefore, the reversed items seemed less important than
did the direct items for measuring curiosity. In accord with state-trait
theory, the C-Trait scale was less situationally sensitive than the C-State
scale, but the retest reliability coefficient (see above) was expected to have
been at least in the high .8 to low .9 range, given the short time interval
interposed between testing occasions (in regard to the C-Trait scale).
Nevertheless, ANOVA results indicated significant treatment effects for
C-State scores, but *none* were found for C-Trait scores.

In a second published study, Naylor (1981) reconstructed the original
C-State and C-Trait scales and named the new scales the Melbourne
Curiosity Inventory (MCI). In this version of the C-State and C-Trait
scales (pp. 174 and 176, respectively), Naylor replaced the reversed items with
direct ones, in view of the apparent lack of construct validity of the former
items. In several studies, Naylor investigated the reliability and validity of

the new unidirectionally worded C-State and C-Trait scales. The C-Trait form of the MCI was administered to samples of 98 graduate students, 218 undergraduates, 339 secondary students in grades 10, 11, and 12, and 134 similar secondary students, from 1977 through 1979. Mean scores ranged from 55.62 to 57.94 (standard deviations from 8.12 to 9.94), and alpha coefficients varied from .84 to .93. Test-retest reliability obtained on 103 college graduates over a 25-day interval was .83 and that on 82 grade 10 male students over a 5-week period was .77. The C-State form of the MCI was likewise administered to groups of 170, 146, 150, and 107 secondary school students during 1978 and 1979. Mean C-State scores ranged from 51.06 to 61.48 (standard deviations from .87 to .92), while alpha coefficients varied from .87 to .92.

Naylor factor-analyzed the MCI items following administration of the C-Trait scale on one occasion and the C-State scale on two subsequent occasions. Subjects were 262 grade 10 and grade 12 secondary students in eight Melbourne metropolitan schools. The total 60 items (20 items from each measurement occasion) were subjected to principal-components analysis. Varimax rotation of the first three components supported the separation of C-Trait items and C-State items on each testing occasion. Unfortunately, this design did not permit the conclusion that the C-Trait scale was more stable than the C-State scale, although Boyle (1979b) did establish this fact with the earlier version of the scales. Nevertheless, Naylor did report some evidence of discriminant validity for both the C-State and C-Trait forms of the MCI, in regard to obtained correlations with the subscales of the Strong Campbell Interest Inventory (SCII; Campbell, 1977), designed to measure the Holland (1973) interest categories.

Independently of the Melbourne research group, Spielberger, Peters, and Frain (1980), working at the University of South Florida, developed a State-Trait Curiosity Inventory (STCI) similar in design to Naylor and Gaudry's (1976) scales, except that it comprised only 15 instead of 20 items in each of the C-State and C-Trait scales. The Spielberger scales each comprised only 8 direct and 7 reversed items, with a consequent reduction in reliability over the Naylor and Gaudry scales. The instructions prefacing the two sets of scales were almost identical, the response categories were identical, and the items were mostly similar. This commonality was probably due to the use of the STAI as a model for constructing the C-State and C-Trait scales by both the Melbourne and Florida research teams. While Naylor and Gaudry's scales demonstrated concurrent and discriminant validity (Boyle, 1979b, p. 75), according to Spielberger et al., the median correlation between their STCI scales and Zuckerman's (1971) SSS was only .16, and that between the STCI and OTIM subscales was only .20. Frain's (1977) factor analysis of the STCI cast some doubt on the construct validity of the STCI, since both the C-State and C-Trait scales

loaded the same factor (however, Boyle, 1979b, reported a similar finding with the Naylor and Gaudry scales loading a bipolar secondary factor, as stated above). Peters (1978) reported that the Spielberger C-Trait scale was more valid than the C-State scale (in contrast to the greater reported validity of the Naylor and Gaudry C-State scale over the C-Trait scale). Voss and Meyer (1981) reported that the Spielberger C-State scale was situationally sensitive, as expected from state-trait theory.

Subsequently Spielberger (1980) and Spielberger, Barker, Russell, Silva De Crane, Westberry, Knight, and Marks (1980) have constructed a State-Trait Personality Inventory (STPI) consisting of six 10-item state-trait scales for anxiety, curiosity, and anger, thereby amalgamating the state-trait research at Florida into a single psychometric measure. The STPI measures both state and trait aspects of each construct. Spielberger and his colleagues (Spielberger, 1980) now generally use the STPI rather than the STCI when measuring curiosity. Response categories and items for the STPI were taken directly from the STAI and STCI, with the addition of items pertaining to anger. Alpha coefficients of internal consistency ranged from .81 to .87 for the 10-item C-Trait scale, and from .78 to .84 for the corresponding C-State scale. Of the 10 items in each subscale of the STPI, only 2 were in the reversed direction for each of the C-State and C-Trait scales, thereby minimizing the adverse influence of the reversed items, particularly apparent with the Naylor and Gaudry scales. Using a principal components plus varimax factoring procedure, Spielberger et al. reported a three-factor solution in which both the C-State and C-Trait subscales of the STPI loaded the same factor. This finding concords with that of Frain (1977) and suggests that the STPI curiosity subscales lack adequate construct validity (in terms of their purported state and trait characteristics).

LIMITATIONS OF STATE-TRAIT CURIOSITY RESEARCH

A number of methodological inadequacies are evident in the above studies on state-trait curiosity, both in regard to the nature of the C-State and C-Trait scale construction and in relation to the factor-analytic methodology employed by both the Melbourne and Florida research groups. Limitations include the reliance on narrow scales with high item homogeneity, the use of univariate scales rather than multivariate scales, the employment of transparent self-report items rather than objective items, and the perseverative dependency on outmoded, defective methods of factor analysis.

As for the first of these, all the above state-trait investigators, without exception, have attempted to maximize internal consistency (item

homogeneity/redundancy). Cattell (1973, pp. 357-379) argued cogently that the items of a scale should not exhibit excessively high homogeneity if the scale is to *broadly* measure a given construct, and if the item redundancy is to be minimized (the alpha coefficient might well be relabeled the coefficient of item redundancy). Clearly, the original C-State and C-Trait scales of Naylor and Gaudry (1976), the newer MCI scales (Naylor, 1981), and the C-State and C-Trait scales in the STCI (Spielberger et al., 1980) and also in the STPI (Spielberger, Barker, et al., 1980; Spielberger, 1980) are all narrow, since their respective items measure the same limited aspects of the curiosity construct, in view of the high alpha coefficients reported in every case. Kline (1979, p. 3) argued that alpha coefficients should be kept below .7 for best results. The common notion that internal consistency estimates reflect the reliability of a scale is erroneous, as noted earlier by Cattell et al. (1964). However, reliability, as indexed by test-retest (dependability and stability) coefficients, has been tentatively supportive of the state and trait properties of some of the scales (e.g., Boyle, 1979b; Naylor, 1981).

The second defect involves the construction of univariate C-State and C-Trait scales designed only to measure the curiosity construct. The difficulty with using single-dimension scales is that elevations in other motivational states such as anxiety, stress, or depression, for instance, may go undetected. While C-State scores may alter as a result of experimental intervention, the greatest effect might involve other unmeasured states. Change in the C-State score might even result from a high correlation with such unmeasured states. When using a univariate scale, one can never be certain that elevation of C-State scores is really due to heightened curiosity per se. Only Spielberger, Barker, et al. (1980) and Spielberger (1980) have even attempted to construct a multivariate measure that includes both C-State and C-Trait subscales (namely, the STPI). Accordingly, the Florida research team has made a significant advance in measurement approach. Clearly, psychometry of the future must take a multivariate perspective. Even so, two additional problems with the STPI concern the few constructs measured (only curiosity, anxiety, and anger) and the attempt to keep the measure relatively brief, with only 10 items in each subscale. Compared with the 20-item scales of Naylor and Gaudry (1976) and of Naylor (1981), the reliability of the corresponding STPI subscales is necessarily diminished. Spielberger and his colleagues would have done better to keep the number of items in each subscale at 15 (as per his STCI).

Another serious difficulty with the C-State and C-Trait scales developed both at Melbourne and at Florida is the obvious superficiality and transparency of the items themselves. In an attempt to overcome susceptibility to response sets, reversed items had been employed by Naylor and Gaudry (1976). However, such items were shown to measure boredom

rather than curiosity (Boyle, 1979b; Naylor, 1981). Spielberger initially included seven reversed items in each of his STCI scales, but in his STPI he incorporated only two such items. Spielberger's less radical exclusion of reversed items (than Naylor's in his MCI) was evidently an attempt to obtain at least some minimal index of the respondent's susceptibility to response sets such as social desirability and acquiescence, and thereby to estimate the validity of the subject's responses. The MCI must be regarded as less than satisfactory in this regard, as compared with the STPI.

A more fundamental defect was the use of face-valid self-report items to measure complex motivational states and personality traits. Being transparent, such items are prone to distortion ranging all the way from inadequate self-awareness to deliberate faking. It is necessary, therefore, to design items that objectively measure the curiosity construct but at the same time have no immediately obvious connection with curiosity. Such pencil-and-paper items have been designed and employed in objective tests of motivation dynamics, as in Cattell et al. (1964), with the Motivation Analysis Test (cf. Boyle, 1983b). Curiosity investigators need to pay heed to these contemporary developments in test construction if the field of curiosity research is to advance beyond its current superficiality.

Finally, the adherence to inadequate factor-analytic methodology in both the Australian and United States research groups has unduly hindered progress in the development of state-trait curiosity measures. Often, sample sizes have been too small to justify the use of factor analysis at all (e.g., Devlin, 1976; Dickie, 1977). As Boyle (1983b) indicated, the sample size should satisfy the minimal criterion of at least 250 subjects. Insufficient numbers of subjects likely result in factors with lowered validities. Moreover, there has been unjustified reliance on orthogonal varimax rotation, coupled with principal-components analysis, and the factor extraction number often determined by the eigenvalue greater than unity (Kaiser-Guttman) criterion. The importance of correct factor-analytic methodology cannot be overstated (cf. Cattell, 1973, pp. 282-287; 1978; 1979, p. 351; Kline, 1979, pp. 38-41; Boyle, 1983b). With principal components, spurious common factor variance is added into the solution due to inflated communality estimates (Lee & Comrey, 1979, p. 301). This reduces the psychological meaningfulness of the derived components, despite the mathematical elegance of the derivations.

Use of orthogonal rotation fails to achieve simple structure (Vaughan, 1973; Burdsal & Vaughan, 1974; Nie, Hadlai Hull, Jenkins, Steinbrenner, & Bent, 1975, p. 473; Bolton, 1977; Loo, 1979). It permits only a special resolution of the multitude of outcomes possible with oblique rotation. Adherence to the Cattell guidelines allows a unique terminal solution to emerge. As Cattell (1978, p. 137) indicated, in the extremely unlikely event

that hyperplanes are orthogonal, an oblique solution carried to maximum simple structure (i.e., over and above the analytical solution produced by the push-button computer package) will stop at the appropriate special orthogonal position. Cattell (1978, p. 142) pointed out that it is necessary to utilize a topological rotation (such as Rotoplot; Cattell & Foster, 1963) in order to (a) reduce excessive or bizarre angles among reference vectors, and (2) to maximize the hyperplane count within a reasonably narrow band width (usually ± .10). As for the correct factor extraction number, Cattell and Vogelmann (1977), Cattell (1978, p. 91), Horn and Engstrom (1979), and Hakstian, Rogers, and Cattell (1982) have all demonstrated that the psychometric scree test is more accurate than the Kaiser-Guttman (K-G) criterion in three out of four cases. Most state-trait curiosity studies have relied on the K-G criterion, although some studies (e.g., Nichols, 1976; Dickie, 1977; Spielberger et al., 1980; Naylor, 1981) arbitrarily chose the number of factors to extract and rotate. Spielberger (1980) stated that, in regard to factor extraction number, "psychological meaningfulness is the ultimate criterion" see also Spielberger, Vagg, Barker, Donham, & Westberry, 1980, p. 99). However, it is absolutely critical that the correct factor extraction number be determined, as the psychological meaning-fulness of the derived factors will be reduced with the incorrect factor number. An objective test such as in the maximum-likelihood factor-analytic method (Rao, 1965; Jöreskog, 1977) does result in reliable decisions as to the correct number of factors to extract for a given sample size. However, with very large samples (say, 1,000 subjects), the statistical maximum-likelihood method extracts trivial factors (Cattell, 1979). In these circumstances, it is necessary to check the accuracy of the factor extraction number with the psychometric scree test. Both methods are, nevertheless, better than the K-G criterion in most instances (Cattell, 1973).

Obtaining accurate communality estimates by an interative principal-factoring procedure (far superior to the mathematical principal-components method) is simply not achievable without the correct factor extraction number. It is also desirable to test the significance of the obtained simple structure factors using Kameoka and Sine's (1978) statistical tables. Clearly, the percentage of variables (C-State and C-Trait items) in the ± .10 hyperplane band width for the final obliquely rotated solution should lie between 55 and 85% (Boyle, 1983b). The higher the hyperplane count, the better. None of the above state-trait curiosity studies has even determined the hyperplane count, and none has assessed the statistical significance of the obtained factors.

Evidently there has been much futile discussion of nonsignificant, trivial factors by both the Melbourne and Florida research groups. Given the lack of insight into correct factor-analytic methodoloty, the state-trait

curiosity factor-analytic results must be regarded as unreliable and possibly invalid. Unfortunately, journal editors have not been alert to such "sloppy" factor-analytic methodology in the studies by Boyle (1979b), Naylor (1981), and Spielberger et al. (1980), to mention but a few instances. Indeed, the psychological literature is replete with ad hoc factor-analytic findings and methods. This represents a severe indictment of the appalling lack of critical factor-analytic awareness. Also, the degree of invariance of obtained factor solutions needs to be checked across different state-trait curiosity studies, using congruence and salient-variable similarity indices (Cattell, 1973, 1978; Cattell & Butcher, 1968). For totally thorough factor-analytic work, the invariance across studies of higher-order structure should be checked. The obvious lack of factor-analytic sophistication in the existing studies of state-trait curiosity scales must be recognized and acted upon if significant new insights into human curiosity are to be achieved.

CONCLUSION

Overall, the studies alluded to in this paper provide some tentative support for the state-trait curiosity model (a model culminating from the work of numerous curiosity theorists, and from a similar model in the anxiety domain). The reliability and validity of the various C-State and C-Trait scales has received some support. These scales require refinement, however, in their breadth of measurement (item homogeneity needs to be reduced in order to diminish item redundancy), with a greater diversity of items being used to more broadly measure the curiosity construct, in the use of multivariate rather than univariate scales, in the use of objective items instead of face-valid, transparent self-report items, and in the correct application of factor-analytic methodology. If subsequent investigations were to take into account these several considerations, research gains in the field of curiosity should be substantial indeed.

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