Can Personality Traits Be Inferred Automatically? Spontaneous Inferences Require Cognitive Capacity at Encoding

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Previous research showed that people can make trait inferences from single behaviors described in sentences, without either intentions to do so or awareness of having done so. This suggested that these inferences might be automatic. By definition, "automatic" cognitive processes occur without intentions or awareness, without effort, and without using capacity-limited cognitive processing resources. Winter, Uleman, and Cunniff (1985) attempted to manipulate available cognitive capacity by varying the difficulty of the concurrent cognitive task. This did not affect unintended trait inferences, suggesting that these are automatic by this criterion. But they had no direct measure of available cognitive capacity. In the present study, we added a probe reaction time measure of capacity to their procedure and extended the range of task difficulties. Earlier findings of trait inferences without intentions or awareness were replicated, but there was also evidence that the concurrent task interfered with the trait inference process. Hence, although trait inferences can be "spontaneous" (occurring without intentions or awareness), subjectively effortless, and difficult to disrupt with a concurrent task, they are not entirely automatic because they use capacity-limited resources. These results also confirm that the cued-recall evidence for spontaneous trait inferences reflects important encoding and not merely retrieval phenomena. © 1992 Academic Press, Inc.

What are the minimal conditions necessary for people to go beyond the mere perception and categorization of objects and engage in more complex cognitive processing, such as inferring personality traits from other people's actions? Do such complex cognitions require volition (intentions, incentives, or particular motivating conditions)—or can they simply occur as an unintended part of comprehending the passing scene? And if such unintended inferences do occur, can they occur outside of consciousness?

Within the past decade, these two questions—the consciousness question and the volitional question—have been extensively examined in social cognition. There seem to be two general approaches to the volitional question. One approach asks: What conditions increase the frequency of social inferences? This approach looks for motivational means to increase inferences, and it has produced evidence that social inferences are more likely in the face of direct questioning, instructions to form impressions, unexpected events, failure, or outcome dependencies (e.g., Hastie, 1984; Pittman & D'Agostino, 1985). However, showing that a particular

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motivating condition increases the frequency of inferred traits does not imply that motivation is necessary (contrary to claims by Bassili and Smith (1986) and D'Agostino (1991)). Likewise, showing that inferences occur without some motivating condition does not preclude the ability of motivation to increase the frequency of inferences.

The other approach is the one we posed initially: What are the minimal conditions necessary for social inferences to occur, or for their effects to be detected? Our initial minimal-conditions approach to the volitional question requires supplementing or even abandoning traditional self-report measures of social inferences, because direct questioning may artificially evoke inferences that would not otherwise occur. Investigators interested in this issue have used less reactive, indirect measures, such as reaction time (Smith & Miller, 1983). Winter and Uleman (1984) developed a cued-recall technique for assessing spontaneous trait inferences. Their method was based on Tulving's principle of encoding specificity, which holds that “specific encoding operations performed on what is perceived, determine what is stored; and what is stored determines what retrieval cues are effective in providing access to what is stored” (Tulving and Thomson, 1973, p. 369). Thus if people make inferences about events at comprehension, these should be stored with and serve as effective retrieval cues for the events.

Winter and Uleman reported two studies using sentences that describe events that pretest subjects had explained by inferring the actors’ personality traits (see Table I for examples). These traits were then used to cue recall of the sentences for a second set of subjects, who read them briefly for a memory study, without any instructions to make attributions. Trait cues produced better recall than no cues. They also cued recall at least as well as strong a priori semantic associates of important sentence words. These latter cues control for the possibility that trait cues may facilitate sentence retrieval through their own a priori associations to the relevant words in semantic memory, rather than through links in episodic memory established at encoding.

Subsequent questioning further revealed that subjects were unaware of having made trait inferences and that their infrequent reports of doing so did not correlate with the effectiveness of the trait cues. This bears directly on the consciousness question raised above. Apparently, people can make such complex inferences without either volition or consciousness.

Winter and Uleman called trait inferences that occurred without either intentions or awareness “spontaneous” trait inferences. Cognitive processes that occur without intentions or awareness have also been characterized as “automatic,” in contrast with controlled, strategic, or attentive processing (Kahneman & Treisman, 1984; Logan, 1985; Shiffrin, 1988). Because automatic processes are also relatively unaffected by limitations in available cognitive capacity, it is more difficult to interfere with them. Winter and Uleman’s results raised the possibility that trait inferences may occur automatically. To explore this, Winter, Uleman, and Cunniff (1985) modified their paradigm to obtain better measures of awareness, eliminate any possible intentions to infer traits, and vary the cognitive capacity available for sentence inferences. Subjects were told that they were in a study of memory for digits, with sentences serving as distractors. On each of 16 trials, a series of five slides with different numbers was shown, followed by a
TABLE 1
Representative Sentence Stimuli and Their Recall Cues

<table>
<thead>
<tr>
<th>Sentence</th>
<th>Trait</th>
<th>Recall cue type</th>
<th>Gist</th>
</tr>
</thead>
<tbody>
<tr>
<td>The accountant takes the orphans to the circus.</td>
<td>Kind-hearted</td>
<td>Numbers</td>
<td>Enjoyable outing</td>
</tr>
<tr>
<td>The barber loses 20 lbs in 6 weeks.</td>
<td>Will power</td>
<td>Hair</td>
<td>Dieting</td>
</tr>
<tr>
<td>The businessman steps on his girlfriend’s feet during the foxtrot.</td>
<td>Clumsy</td>
<td>Three-piece suit</td>
<td>Dancing</td>
</tr>
<tr>
<td>The child tells his mother that he ate the chocolates.</td>
<td>Honest</td>
<td>Toys</td>
<td>Confessing</td>
</tr>
<tr>
<td>The decorator tells the dentist all about her neighbors’ habits.</td>
<td>Nosy</td>
<td>Interior</td>
<td>Talk</td>
</tr>
<tr>
<td>The deliveryman loses his savings in a poker game.</td>
<td>Compulsive</td>
<td>Milk</td>
<td>Gambling</td>
</tr>
<tr>
<td>The electrician gets a promotion and a raise.</td>
<td>Good worker</td>
<td>Wires</td>
<td>Advancement</td>
</tr>
<tr>
<td>The mailman picks his teeth during dinner at the fancy restaurant.</td>
<td>Ill-mannered</td>
<td>Letters</td>
<td>Eating</td>
</tr>
<tr>
<td>The minister gets his poem published in The New Yorker.</td>
<td>Talented</td>
<td>Church</td>
<td>Writing</td>
</tr>
<tr>
<td>The plumber slips $50 into his wife’s purse.</td>
<td>Generous</td>
<td>Pipes</td>
<td>Giving</td>
</tr>
<tr>
<td>The receptionist steps in front of the old man in line.</td>
<td>Rude</td>
<td>Telephone</td>
<td>Cutting in front</td>
</tr>
<tr>
<td>The professor invites the newcomers to his house.</td>
<td>Friendly</td>
<td>Teacher</td>
<td>Welcome</td>
</tr>
<tr>
<td>The secretary solves the mystery halfway through the book.</td>
<td>Clever</td>
<td>Typewriter</td>
<td>Reading</td>
</tr>
<tr>
<td>The tailor carries the old woman’s groceries across the street.</td>
<td>Helpful</td>
<td>Clothes</td>
<td>Assisting</td>
</tr>
</tbody>
</table>

sentence. Subjects were to read the sentence aloud, repeat it, and then recall the number series. Since sentences were distractors rather than targets to be remembered, any possible intentions to infer traits were eliminated. Awareness of encoding strategies was assessed immediately after the last sentence was read, rather than 10 min later after recall. Finally, available cognitive capacity was varied by using an easy and a difficult number series (Logan, 1979). The easy series had single digits on each slide while the difficult series had double and triple digits.

Recall results showed that spontaneous trait inferences occurred even under these conditions of reduced attention and no intentions to elaborate or attribute. Awareness was unrelated to cues’ effectiveness for men, and was only weakly related for women. Manipulation checks showed that digit recall was much poorer for the difficult series, and it was rated more difficult. But disposition-cued recall was unaffected by the digit condition manipulation of cognitive capacity. All of this suggested that trait inferences can be more automatic than previously suspected.

However, there are at least three reasons for caution in characterizing the trait inference process as automatic. First, the paradigm requires some control processing, particularly in the allocation of attentional resources and apparently much more control processing than paradigms typically used to study automatic
attentional processes (e.g., Schneider, Dumais, & Shiffrin, 1984; Bargh & Pratto, 1986) or automatic priming of social categorization (Bargh, 1984). That is, the inference tasks are relatively complex, so that some subprocesses may be automatic while others are not. With the exception of extremely simple tasks that require less than 200 to 300 ms for execution, "it would be hard to find any task that is not accomplished through the use of both automatic and control processes" (Schneider et al., 1984, pp. 2–3). Automaticity is a matter of degree for complex tasks like these. Second, there is some evidence (Fisk & Schneider, 1984; Kolers, 1975) that control processes are required to modify long-term memory (LTM). Since much of the indirect evidence for attributional processing described above depends on changes in LTM, control processing must have been involved to some degree. Third, the evidence from Winter et al. (1985) for noninterference by concurrent cognitive activity is open to another interpretation. Cognitive capacity available for inferences may not have actually varied between digit conditions. Because no direct measures of cognitive capacity were obtained, the possibility remains that subjects did not try as hard to remember the difficult series. If they attended and rehearsed less, they could still have rated these digits more difficult and remembered fewer of them, without using any more cognitive resources on them than on the easy digits.

Therefore, it seemed important to replicate Winter et al. (1985) with two changes designed to address these issues. First, a probe reaction time measure of cognitive capacity was added. This required that throughout the digit memory task with sentence distractors, subjects also had to monitor a signal light. Whenever the light came on, they had to press a reaction time key as quickly as possible. Longer reaction times indicate less available cognitive capacity (Posner & Boies, 1971). Second, a simpler digit condition was added to extend the range of cognitive loads and to avoid the possible ceiling effect on expended effort noted above. In the new digit series, each of the five number slides shown on a given trial contained the same digits, though these digits differed from trial to trial.

We predicted that the probe reaction time (RT) measure would confirm significant differences in available cognitive capacity between the easy and the difficult digit conditions used by Winter et al. (1985) and would show that these conditions require more capacity than the new identical digits condition. If trait attributions are automatic and not capacity limited, digit difficulty (and therefore available cognitive capacity) should have no impact on disposition-cued recall. Disposition-cued recall should thus exceed noncued recall and be greater than or equal to semantic (actor)-cued recall. If, however, disposition-cued recall does require cognitive capacity, it should vary with digit condition.

METHOD

Subjects were 108 volunteers from NYU's introductory psychology course who signed up for a study called "Memory for Digits," in partial fulfillment of course requirements. They were run individually.

Materials included 14 stimulus sentences described in Winter, Uleman, and Cunniff (1985), plus 2 others used in previous research. Each one describes an
actor designated by an occupational role, performing a simple action that is unrelated to the occupation, without reference to internal states such as emotions or intentions. Pretesting established that all sentences had the following five characteristics: Intentional causal attributions for the events were made to the actor rather than to the situation. Intentional characterizations of the actor yielded consensual trait words. Intentional characterizations of the activity yielded consensual action gists, which differed from the trait words. The associative strength between the trait word and its sentence roughly matched the associative strength between that sentence and its gist word in a paired-associates learning task. Finally, there were consensual semantic word associations to the actor’s occupational roles. Thus, there were three different words that could be used for cued recall of each sentence: a trait, an action gist, and a semantic word association to the actor. See Table 1 for examples of sentence stimuli and cues, and see Winter et al. (1985) for additional details.

Three digit series were used. The multiple-digit sequences consisted of three double and two triple digits (e.g., 27–14–973–582–10). The single-digit sequences consisted of five different single digits (6–7–0–3–9). Both of these were also used in Winter et al. (1985). The new identical-digit sequences consisted of five repetitions of the same digits (24–24–24–24–24).

Probe reaction times were measured with a white signal light and response key connected to a timer accurate to the nearest tenth of a millisecond. The light and key rested in front of subjects on a writing surface. Whenever the experimenter activated the timer with a silent switch, the light came on until the subject depressed the key, thereby also stopping the timer. A 2-min anagram distractor task from Winter et al. (1985) was also used to allow short-term memory delay and to remove the sentence stimuli from working memory. This consisted of 12 anagrams or scrambled words, unrelated to the sentences and presented in groups of three on four slides. The cued-recall sheets contained a list of retrieval cues at the left of a series of lines, as well as completely blank lines for noncued sentence recall.

The procedure was identical to that of Winter et al. (1985) except for the addition of the identical-digits condition and the probe RT measure. Written instructions, which were also reviewed orally, stated that on each of 16 trials a five-number sequence would be shown on the screen, one number at a time. The projector would advance after the subject read each number aloud. After the fifth number, a distractor sentence would be shown, which the subject was to read aloud and then repeat, looking away from the screen. Then with a blank slide projected, the subject was to recall the digit sequence aloud in the next 10 s. In addition, subjects were simultaneously to monitor the signal light, which could light up at any time. Whenever it did, they were to press the response key as quickly as possible. Subjects had two practice trials with the light and key.

During the 16 trials, the experimenter sat slightly behind and to the left of the subject, to operate the Kodak Carousel slide projector and reaction time probes as unobtrusively as possible. He or she also recorded subjects’ digit recall performance manually. Sentences were presented in a different random order to each subject. Probe reaction times were obtained on trials 2, 5, 8, 10, 12, and 13, and always between the presentation of the fifth number and the sentence.
On the 16th trial, after repeating the sentence but before recalling the digits, subjects were asked to report the thoughts they had in reading the sentence. Then they used 0- to 10-point scales to rate how much they thought about visual images, word associations, what caused the event, and the actor’s personality in the last sentence, thus providing measures of immediate awareness of spontaneous inferences for the last sentence. They also rated the digit task’s difficulty. Then they recalled the last number sequence and worked on the 2-min anagram distractor task. Finally, they were unexpectedly asked to recall the 16 sentences they had read as distractors, using the cued-recall sheets.

The ANOVA design contained between-subject factors of Digit Condition (multiple, single, and identical), and Block–Cue Pairing for recall. This factor resulted from using four different cued-recall sheets, each containing all four cue types (dispositional, gist, semantic, and no cue). Thus, Cue Type was a four-level within-subjects factor. The 16 sentences were divided into four blocks, and cue types were rotated through blocks in a Latin square design to produce the four block–cue pairings on the four recall sheets. In other words, each subject was exposed to only one of the three digit conditions. All subjects were given all four cue types on their cued-recall sheets, but only one particular cue for each of the 16 sentences; cue types and sentences were counter balanced across subjects through four different cued-recall sheets in a Latin square design.

The other within-subjects factor was Sentence Part. Each sentence contained an actor, verb, object, and modifying phrase. Sentence recall was scored leniently, with each of the four parts scored present (1) or absent (0). Interscorer agreement has exceeded 96% in previous studies. Two scorers scored all recall sheets, and disagreements were resolved through discussion. This yielded a $3 \times 4 \times 4 \times 4$ factorial split-plot design for recall: Digit Condition $\times$ Pairing $\times$ Cue Type $\times$ Sentence Part. The last sentence was omitted from all analyses of mean recall, because the awareness questions had highlighted it.

**RESULTS**

**Effect of Digit Conditions on Cognitive Capacity**

One purpose of this study was to determine whether Winter et al. (1985) had effectively varied cognitive capacity. A 3 (Digit Conditions) $\times$ 6 (Trials) ANOVA was performed on RTs. RTs $> 1.5$ s were excluded; these constituted less than 1% of the responses. There was a main effect for digit condition, $F(2, 92) = 3.36$, $p = .039$, with RT increasing from the identical-digits (586 ms) to the single-digits (659 ms) condition, $t(70) = 2.67$, $p = .009$, but not from the single to the multiple (674 ms) condition, $t(69) = 0.49$, $p > .50$. That is, probe RT results suggested that Winter et al.’s two levels of digit task difficulty had not effectively manipulated available cognitive capacity.$^4$

$^4$ We were concerned that experimenters might have inadvertently cued subjects on the RT trials; if this had happened, RTs would have decreased in later trials. RTs did change over trials, $F(5, 460) = 3.47$, $p = .004$, decreasing over the first trials, apparently with practice, but then increasing with either fatigue or loss of interest: 652, 614, 594, 621, 638, and 653 ms. This pattern effectively rules out our concern with experimenter cuing. There was no Digit Condition $\times$ Trial interaction, $F < 1.0$. 
Simple ANOVAs showed that the effect of digit condition on digit memory and digit difficulty ratings was highly significant, Fs(2, 105) > 22, ps < .0005. Memory varied from 33.8% of the multiple digits through 83.9% of the single digits to 87.5% of the identical digits. The first two differed, t(70) = 23.4, p < .0005, but the last two did not quite differ, p = .092. Informal observations and the surprising fact that memory for identical digits did not approach 100% suggest that the identical-digits condition bored subjects and failed to engage their full attention. This is consistent with the RT results above and with the ratings of the task’s difficulty. These varied from 6.86 for multiple digits through 5.89 for single digits, t(70) = 2.06, p = .043, to only 3.69 for identical digits, ts(70) > 4.60, ps < .0005. Note that results with these two measures replicate Winter et al.’s (1985) findings of differences between the multiple- and the single-digits conditions, even though their conclusion that these conditions differ in available capacity is not supported by the more direct and relevant RT measure.

**Sentence Recall**

Miscued recall—i.e., sentences or sentence parts that subjects indicated were recalled with the aid of cues intended for other sentences—was dropped. In addition, all 16 recall scores (4 cue types × 4 sentence parts) showed significant positive skewness, ps < .001. The square root transformation eliminated skewness for 7 of these scores (ps > .05) and reduced it for all others, so transformed scores were used in all analyses.

The 3 (Digit Condition) × 4 (Block-Cue Pairing) × 4 (Cue Type) × 4 (Sentence Part) ANOVA yielded the expected significant effects for cue type, F(3, 288) = 19.55, p < .0005, and for Cue Type × Sentence Part, F(9, 864) = 34.2, p < .0005. Gist-cued recall (19.3%) exceeded disposition-cued recall (14.4%; t(107) = 2.24, p < .03), which exceeded semantic-cued recall (11.8%), although not significantly, p > .20. All three exceeded noncued recall (4.8%), ts(107) > 5.6, ps < .0005.

The Cue Type × Sentence Part interaction was similar to those of previous studies (Winter et al., 1984, 1985), with semantic cues cuing sentence actors best, and gists and dispositions cuing predicate parts best. Semantic cues worked better for actors (21.6%) than did other cues, ts(107) > 3.6, ps < .0005, and gist (12.4%) and disposition (10.0%) cues worked better for actors than no cue (4.0%), ts(107) > 3.10, ps < .0002. Gists cued verbs (20.0%), objects (22.6%), and phrases (22.3%) better than disposition cues did (15.4, 16.7, and 15.7%, respectively), although only the last two differences reached significance, ts(107) > 2.06, ps < .05. Disposition cues were better than semantic cues for all three predicate parts (8.5, 8.8, and 8.5%, respectively, ps < .002). Semantic cues were better than no cues (5.5, 4.9, and 4.9%, respectively, although only the last two differences reached significance, ps < .05.

5 In addition, there were some uninterpretable higher order interactions of block-cue pairing with cue type and sentence part: Pairing × Cue Type, F(9, 288) = 1.93, p < .05; Pairing × Sentence Part, F(9, 288) = 2.76, p = 2.76, p = .004; and Pairing × Cue Type × Sentence Part, F(27, 864) = 2.70, p < .0005.
### Effects of Cognitive Capacity on Sentence Recall

Winter et al. (1985) found no effects on recall for digit condition, $F$s $< 1.0$. In the present study, digit condition had a significant effect, in a Digit Condition $\times$ Sentence Part $\times$ Cue Type interaction, $F(18, 864) = 1.68$, $p = .037$. Table 2 presents the recall percentages for this interaction. Significant differences between cue types are noted, within each of the 12 combinations of digit condition and sentence part, so that cues’ effectiveness within digit conditions can be readily compared.

In order to examine the effects of digit conditions on cued recall of sentence parts more closely, we performed a separate 3 (Digit Condition) $\times$ 4 (Block-Cue Pairing) $\times$ 4 (Sentence Part) $\times$ 2 (Cue Type) ANOVA for the three cue types, with each ANOVA including one cue type and noncued recall. All three ANOVAs showed the expected effects for sentence part, for cue type, and for Sentence Part $\times$ Cue Type, $F$s $> 6.6$, $ps < .0005$. But we were particularly interested in the effects of digit conditions. There were none for semantic cues ($ps > .20$). However, there were revealing effects of digit conditions on both gist- and disposition-cued recall.

Gist-cued recall showed two interactions with digit condition, Digit Condition $\times$ Sentence Part, $F(6, 288) = 3.63$, $p = .002$, and a three-way interaction with cue type, $F(6, 288) = 2.57$, $p = .02$. As in previous research, gist cues in the identical-digits condition were more effective than no cues for all sentence parts (see Table 2). The significant superiority for actor recall was lost under single digits, and the superiority to noncued recall of the phrase was additionally lost under multiple digits. Thus, gist-cued recall exceeded noncued recall for first
four, then three, and finally two sentence parts under identical, single, and multiple digits, respectively.

Disposition-cued recall also showed a Digit Condition × Sentence Part × Cue Type interaction, $F(6, 288) = 2.54, p = .02$. The effectiveness of disposition cues showed a decline sharper than that of gist cues did from the identical-digits to the multiple-digits condition. Under identical digits, disposition-cued recall of all sentence parts was superior to noncued recall, as in past research. Under single digits, only predicate recall was facilitated. But under multiple digits, disposition-cued recall was not significantly higher than noncued recall for any sentence part. Thus, across digit conditions, superiority to noncued recall dropped from four to three to no sentence parts. Table 2 also shows that relative to semantic-cued recall, the drop in the effectiveness of disposition cues across digit conditions was sharper than the drop for gist cues.

Thus, variations in available cognitive capacity at encoding (RTs above) had no significant effects on noncued or semantic-cued recall; compare lines 3, 8, and 13 of Table 2 for the effect of capacity on semantic cued recall (ignoring subscripts), and lines 4, 9, and 14 for its effect on noncued recall. Unexpectedly, however, there were effects of cognitive load on the effectiveness of gist cues (lines 1, 6, and 11), and large effects on the effectiveness of disposition cues (lines 2, 7, and 12). The largest differences for disposition-cued recall occurred between the single-digit and the multiple-digits conditions (lines 7 and 12 of Table 2).

**Awareness**

Subjects' open-ended thoughts about the last sentence were scored for the presence (1) or absence (0) of personality traits. Interrater reliability exceeded 95% agreement. These scores and their ratings on an 11-point scale of how much they thought both about causality and about the actor's personality were our measures of immediate awareness of making trait inferences. Open-ended awareness averaged 10%, and the ratings averaged 3.1 and 4.1, respectively. To see whether these awareness reports were accurate, they were correlated with disposition-cued recall across all sentences except the last, and with the ratio of disposition-cued to total recall over all cuing conditions. None of these correlations approached significance, ranging from $r = -0.07$ to $+0.04$. This suggests that even though the awareness measures were obtained immediately after subjects had read and repeated the final sentence, the subjects had no accurate awareness of having made dispositional inferences.

**DISCUSSION**

We designed this study as an extension of Winter et al. (1985) to further examine the evidence that spontaneous trait inferences are automatic by the criterion of noninterference by a concurrent cognitive load (Logan, 1979). Somewhat unexpectedly, our data indicated that spontaneous trait inferences are not automatic by this criterion, but provided evidence that they do occur at encoding.

By adding a probe RT measure of available cognitive capacity to Winter et al.'s (1985) study of spontaneous trait inferences, we found that their manipulation of
the capacity available for these inferences had not been effective; thus, their results regarding this characteristic of automaticity remain inconclusive. Fortunately, the probe RT results indicated that inclusion of the identical-digits memory task produced a successful manipulation of available capacity, and we were able to directly test Winter et al.'s hypothesis with our cued-recall data. If trait inferences are automatic, then variations in digit difficulty should not affect the effectiveness of trait cues at recall. However, they did: Digit condition affected both trait- and gist-cued recall. More difficult digit conditions produced lower recall cue effectiveness. This indicates that the more difficult digit conditions inhibited or interfered with making trait (and, to a lesser extent, gist) inferences. A concurrent cognitive load can interfere with making trait inferences in the comprehension of trait-implying sentences.

In addition, these results also provide some of the most direct evidence to date that the relative effectiveness of the traits as recall cues reflects the effect of spontaneous trait inferences made at encoding, rather than merely a retrieval effect as some have suggested (see also Newman & Uleman, 1990). The theoretical rationale of earlier studies was based on the principle of encoding specificity. Extensive pretesting was done to rule out retrieval alternatives, but they could not be eliminated entirely (see Wyer & Srull, 1986, pp. 328-329). In the present study, varying available cognitive capacity at encoding selectively affected the effectiveness of disposition cues at retrieval. Decreasing capacity interfered directly with making and encoding trait inferences.

Gist-cued recall also showed some effects of load differences at encoding, suggesting the effectiveness of gist cues partially depends on inferences made then. Because gist cues were not pretested as extensively as disposition cues to eliminate cues with preexperimental associates to the sentences, their effectiveness may reflect a combination of preexperimental associates and new inferences formed at encoding. Thus, we are reluctant to draw any conclusions about the relative importance of encoding processes for gist and trait inferences. The effectiveness of semantic cues was not affected by cognitive load. This is consistent with our previous contention (Winter & Uleman, 1984; Winter et al., 1985) that their effectiveness depends chiefly on preexisting semantic associations in LTM between these words and aspects of the sentence meaning other than their trait and gist implications.

In sum, if disposition-cued recall depended primarily upon retrieval processes, there would have been no relative differences among digit conditions, because the retrieval conditions and materials were the same for all subjects in this study. Only conditions at encoding differed, yet these affected trait (and gist)-cued recall but not semantic- and noncued recall.

Probe RT as a Cognitive Capacity Measure in This Paradigm

There were three versions of the digit memory task. The probe RT measure revealed differences in available capacity between the identical-digits and the other digit conditions, but the effectiveness of disposition cues differed most clearly in comparison with that of multiple-digits condition. This is somewhat
unexpected and may appear to be anomalous. One way to understand how this might have occurred is to consider the possibility that the probe RT task itself may have required cognitive capacity. Imagine that subjects have 5 units of cognitive capacity to allocate among the tasks in this paradigm (an arbitrary assumption, for the sake of presenting the case clearly). Suppose further that each task, because of the nature of its public performance, has some minimal acceptable performance level that requires some minimal amount of cognitive capacity. Suppose that the RT probe task requires a minimum of 1 unit to perform with a low error rate (RTs > 1.5 s < 1%) and that any available resources in addition to this 1 unit can be used to decrease RTs. Also suppose that the identical-, single-, and multiple-digits tasks (Di, Ds, and Dm) must be allocated 1, 2, and 3 units, respectively. And finally, suppose that the sentence reading distractor task (S) consists of two components, each requiring 1 unit of capacity: a sentence representation component (Sr) in which subjects simply read the sentence aloud and repeat it from short-term memory without inferring sentence meanings or storing them in LTM; and a sentence interpretation component that makes inferences and consolidates meanings for storage in LTM (Si). Ordinarily these two components occur together, spontaneously. But the second component, Si, can be dropped if there is insufficient capacity for it. As Craik (1981) notes, “one of the first effects of a reduction in processing resources is a failure to switch in adequate encoding operations, although the subject is still capable of carrying them out” (p. 394).

Instructions established subjects' tasks and priorities, so that enough capacity was allocated to D, RT, and S, that these public performances met reasonable and self-evident criteria: expending reasonable effort on the digit task, D; responding to the RT probe within 1.5 s; and reading and repeating the sentences without errors, S,. Our data and informal observations indicate that all subjects did this. Now suppose that any of the 5 units of capacity that remain after subjects have performed D, RT, and S, are allocated first to Sr, sentence interpretation, and then to decreasing the RTs. This last assumption is critical, because it leads to the pattern of results we obtained. In the identical-digits condition, RT + Di + Sr + Si = 4, so 1 unit remains for reducing RTs. In the single-digits condition, RT + Di + Sr + Si = 5, so no capacity remains for reducing RTs. And in the multiple-digits condition, RT + Dm + Sr + Si = 6, so something other than reducing RTs must be sacrificed. The only process that can be omitted while still meeting the public task demands is Si, and thus trait inferences are not made and/or encoded into LTM. As a result, RTs were lower in the identical-digits than in the single- or the multiple-digits condition, and trait (and perhaps gist) inferences failed to occur only in the multiple-digits condition. These are the results reported above and seen in Table 1.

This simple model can be applied to the Winter et al. (1985) study by dropping the RT term because there was no RT probe in that study. In their single digits condition, Di + Sr + Si = 4; in their multiple-digits condition, Di + Sr + Si = 5. Thus, both conditions are within the overall capacity limit, and Si should have occurred in both. And indeed, their results indicated that disposition- and gist-cued recall were equally effective, and both were superior to noncued recall in both digit conditions. Note that an even more stringent test of this model would
be a test of its prediction that without a probe RT task, cued-recall results for a multiple-digits and an identical-digits condition would not differ. The relevant conditions were recently run in an experiment by Lupfer, Clark, and Hutcherson (1990), and this is precisely what they found: digit difficulty had no effect on trait-cued recall.

Our model highlights a potential ambiguity in interpreting the RTs as a measure of available cognitive capacity. In order for RTs to be interpreted that way, they must depend only on remaining capacity after other tasks have been performed. That is, the paradigm cannot permit subjects to give reducing probe RTs a higher priority in their allocation of cognitive capacity than any other task. As Kantowitz notes, "The logic of the probe task demands that while the primary task (or tasks) limits attention available for probe processing, the probe must not limit processing of the primary task" (1974, p. 124). In our model, this is true for all "public" tasks performances, but not for the private and unobservable sentence interpretation, $S_i$. We have posited that when overload occurs in the multiple-digits condition, subjects can strategically control their allocation of capacity to give the RT task a higher priority than the $S_i$ component of the sentence task. The RT task can thus interfere with $S_i$, violating Kantowitz's condition. The implication of our model is that in multiple-digits condition of the present study, RTs do not reflect the cognitive capacity remaining after all other tasks have been performed, because under this condition the $S_i$ component of the sentence comprehension task is not performed. This is possible because $S_i$ is not a "task" in the usual sense and subjects did not even know they were doing it.

Clearly this model is speculative. It is offered in order to indicate that apparently anomalous findings can be explained, although it does suggest some ambiguities of its own. However, even this ambiguity in interpreting RTs does not negate our basic finding that increasing the concurrent cognitive load at encoding reduces the effectiveness of trait and, to a lesser extent, gist cues at recall.

**Other Considerations and Conclusion**

Two other issues bear some discussion. First, multiple resource models of attention have achieved prominence in recent years. We have assumed throughout this paper that the subject's tasks were all competing for one central and limited cognitive resource. However, there may be multiple resources rather than one single central resource. Such a view raises a host of questions about the meaning of the noninterference criterion of automaticity upon which this study is based (see Logan, 1985; Shiffrin, 1988), and an adequate discussion of them would carry us far beyond our data. Integrating our findings with multiple resource models is not yet possible, and parsimony dictates against trying now.

Second, while our results show that concurrent cognitive tasks can interfere with trait inferences, this interference occurs only under what seem to be fairly extreme cognitive loads relative to most everyday situations. Subjects were covertly rehearsing a five-digit number and being vigilant for the probe RT signal light at the same time that they were reading the sentence aloud. Neither of their primary tasks was overlearned or largely automatic, so the situation was not
analogous to performing a third task while walking and chewing gum at the same time. Relative to most everyday situations, the conditions required for interference with spontaneous trait inferences seem to be very demanding of attention and cognitive capacity (cf. Bargh & Thein, 1985, p. 1144). This suggests that when a person’s primary activity is comprehending behavior or observing someone else or interacting socially, spontaneous trait inferences will occur frequently, without intentions to make them or awareness of having done so.

In conclusion, the present results indicate that trait inferences are not automatic by a capacity criterion. In addition, Moskowitz and Uleman (1987) have found that several sentence processing goals can sharply reduce the frequency of spontaneous trait inferences, as indexed by the level of trait-cued recall. As automatic processes have been characterized as difficult to inhibit or modify (Shiffrin & Dumais, 1981), these findings are relevant to yet another criterion by which these social inferences do not qualify as automatic. Trait inference is therefore best characterized as being a potentially spontaneous process, as defined by Uleman (1989). Spontaneous inferences may occur without intentions or awareness, but they require some cognitive capacity and can be inhibited and terminated. Although they are not automatic, spontaneous processes may produce inferences by combining the output of concepts which are themselves automatically activated.

Most processes of interest to social psychologists are unlikely to be “pure” automatic processes (Uleman, 1989). And though many types of social inferences have now been characterized as “automatic” (see Devine, 1989; Uleman & Bargh, 1989), rarely is there any attempt to specify the relevant parameters. The current program of research on trait inference demonstrates the possibility of systematically doing so.

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