TOT: THE ASSOCIATION STRENGTH HEURISTIC

A Dissertation

by

HYUN CHOI

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2005

Major Subject: Psychology

TOT: THE ASSOCIATION STRENGTH HEURISTIC

A Dissertation

by

HYUN CHOI

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Approved by:

Chair of Committee,   Steven M. Smith
Committee Members, Jyotsna Vaid
                    Takashi Yamauchi
                    Charles Shea
Head of Department,   William S. Rholes

August 2005

Major Subject: Psychology

ABSTRACT

TOT: The Association Strength Heuristic. (August 2005)

Hyun Choi, B.A., Hankuk University of Foreign Studies, Seoul, Korea;

B.S., Southwest Minnesota State University, Marshall, Minnesota;

M.S., Central Michigan University, Mount Pleasant, Michigan

Chair of Advisory Committee: Dr. Steven M. Smith

Three experiments were conducted to examine the effect of association strength on TOT (tip-of-the-tongue states) and recall. Two hundred nineteen undergraduate students studied pictures and names of 24 imaginary animals that were presented on a large computer screen. The strength of association between the cue and target was manipulated by varying the number of times the picture and the name were presented simultaneously, while keeping the number of presentations for each picture or the target constant across conditions. After the study phase, participants were cued by each picture to recall the imaginary animal names. Participants were asked to rate their strength of TOT on a scale ranging 0 to 3 for each item if they could not think of the name at the moment. Participants also made subjective judgments as to how many times they saw the picture and name of the animal co-occur on the same screen at the study phase, and then they performed a recognition test at the end. The results indicated that the frequency and strength of TOTs linearly increased as a function of number of co-occurrences; the correlation between TOT strength and the participants'

subjective estimation of number of co-occurrences was greater than the correlation between TOT strength and the actual number of co-occurrences. This pattern of results was found even when recall increased along with the increase in number of co-occurrences and was more pronounced particularly when recall was reduced either by interference (Experiment 1) or by increased number of critical items (Experiments 2 & 3) and also by a reduced number of co-occurrence conditions and an increased gap between one level to the next (Experiment 3). Results suggest that an increase in association strength concomitantly increases TOT strength especially when the activation of the target is under threshold for recall and that people may use rules of thumb, or heuristic when they report TOTs by estimating the strength of the cue-target association.

For God – my Lord and Savior

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my committee chair and mentor, Steve Smith who helped me on the ideas and details of the dissertation and provided support and guidance during my graduate career. He has been a wonderful advisor.

I would also like to thank my committee members, Jyotsna Vaid, Takashi Yamauchi, and Charles Shea. They were all very supportive and gave me many helpful comments and insights and were always available when I needed them. I am truly grateful to have had them on my committee.

I also want to thank my wife, Hyunsuk Jeong, for her continuous love and support throughout my graduate career. In so many ways, she made it possible for me to get my degree and I will always be grateful.

Finally, I thank my parents, Kichae Choi and Gilja Kim, for their unfailing love and dedication and for supporting me both mentally and financially during my education, and for always remembering me in their prayers. Their support has been invaluable to me.

TABLE OF CONTENTS

Page

Page

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Background

Definition and History of TOT

The knowledge one possesses about the content of one's own memory is often referred to as "metamemory." One such type, called "tip-of-the-tongue," is a state of mind in which people are unable to think of words (i.e., targets) that they are certain they know, and that the target words are on the verge of coming back to them. The tip-of-the-tongue (TOT) state is a well known phenomenon that most people experience frequently. Nevertheless, the specific mechanisms governing the phenomenon are not well known.

Understanding TOT, and more generally, metamemory mechanisms is important because once these mechanisms are known, it will be possible to identify the factors that influence people's judgments on their own memory, also the factors that change their study behaviors and consequently their memory performances. The findings in the study of metamemory can have important implications for understanding a broad range of human behaviors, such as eye witnesses' confidence in their court testimonies, students' study behaviors in educational settings, and frequent TOT experiences in memory performances of older adults and brain-damaged patients (e.g., Alzheimer's disease, aphasia, anomia, and Parkinson's).

_____

This dissertation follows the style and format of *Memory.*

Research interest in the tip-of-the-tongue state can be traced back to as early as 1883 when William James described it as "an active gap" in our consciousness (as cited in A. Brown, 1991). There had been a long research "gap" since then until it was systematically investigated by using a laboratory paradigm developed by Brown and McNeil (1966). In this widely employed laboratory paradigm, definitions of rare words (or pictures of famous people, general knowledge questions) are presented and participants write the target word if they know it. If they do not know the answer, however, they indicate if they are in a TOT state, and they record additional information about the target word, such as the first letter, number of syllables and rhymes.

The early data using this laboratory paradigm suggested that the tip-of-the-tongue state is a true memory phenomenon because the results showed that participants in a TOT state could successfully retrieve the parts or attributes of the target even when they were not able to recall the target *per se*, and subjects experiencing stronger TOTs recalled more accurate partial information about the target (Brown & McNeill, 1966). Supporting evidence was found in the data from naturalistic diary studies in which most TOTs were resolved during the experimental period (e.g., Burke, Worthley, & Martin, 1988; Cohen & Falkner, 1986; Reason & Lucas, 1984).

Trace Access Mechanisms: Partial Activation vs. Blocking

Based on the assumption that the TOT is a memory phenomenon, researchers focused on what causes TOT states and how they are eventually

resolved. In this regard, two prominent hypotheses were suggested; one was the partial activation hypothesis and the other the blocking hypothesis. The partial activation hypothesis ascribed the TOT phenomenon to incomplete activation of the target that fails to exceed the threshold for retrieval, whereas the blocking hypothesis attributed it to temporary inaccessibility of the target word blocked by inappropriate competitors (e.g., similar sounding words) that come to mind in place of the sought-for target. The debate between these two opposing views intensified surrounding a methodological change made by Jones and Langford (1987) from the Brown and McNeill's (1966) laboratory paradigm. Jones and Langford presented a potential blocking word immediately after the definition of a rare word. The rationale of this manipulation was that if TOT states arise due to inappropriate competitors, providing the potential blocking word should also increase TOT incidents. The study found the blocking effect with the words phonologically related to the target, and this result was replicated later (e.g., Jones, 1989). Other studies using a similar methodology, however, found the opposite effect of the supposedly blocking words. For example, Meyer and Bock (1992) found that phonological cues facilitated, rather than blocked, retrieving the target words. Because the phonological cues increased target accessibility as indicated by the increase in the number of correct target retrievals, the researchers concluded that the observed increase in TOT states was due to incomplete retrieval of the target word. Even though the issue has not been

totally resolved to date, there is plenty of research evidence for us to believe that both partial activation and blocking can cause TOT states (Choi & Smith, 2005).

Inferential Mechanisms: Familiarity, Accessibility, Demand Characteristics

Both partial retrieval and retrieval blocking explanations of TOT states are based on the assumption that the target is truly available in memory (e.g., Smith, 1994). The system monitoring the contents of one's own memory apparently bases metamemory judgments on the accessible memory traces of the target. However these are not the only mechanisms that modulate TOT judgments. Later researchers started looking for metamemory mechanisms based on something other than target memory traces.

Researchers call these recently identified metacognitive processes "inferential mechanisms," because in these mechanisms, metamemory judgments are based on inferences, such as how familiar the cue is (e.g., Schwartz & Metcalfe, 1992), or how much information related to the target is known (e.g., Schwartz & Smith 1997), rather than direct access to available target memory traces. One such mechanism is called "the familiarity heuristic" (e.g., Koriat & Lieblich, 1977; Metcalfe, Schwartz & Joaquim, 1993). If the cue is familiar, people are more likely to judge that they are able to remember the target later even though they cannot remember it at the time of making that judgment. Between late 1970's and early 1990's, the evidence for this mechanism had been accumulated mostly in the study of feeling of knowing. For example, Koriat and Lieblich (1977) observed that more elaborated

questions led to higher feeling of knowing for an unrecalled item. Reder (1987, 1988) reported that when general knowledge questions were primed at an incidental test beforehand, the primed questions were judged as answerable more frequently than unprimed questions. Also, increased metacognitive judgments were associated with the amount of domain (area of expertise) knowledge (Reder,1987).

The effect of cue familiarity was also examined in a study of TOT states. In a study particularly relevant to the present proposal, Metcalfe et al. (1993) investigated the effect of cue familiarity contrasted with target memorability on TOT states using a paired associate (plus interference) paradigm. In this study subjects learned four different pair types (e.g., A-B, A-B', A-D, C-D) in a list before learning the A-B pairs in a second list. By doing this the researchers manipulated the number of repetitions of the cue terms to make some cues more familiar to the subject than the other cues. The number of repetitions and the similarity of the target was also manipulated independently of cue familiarity; that is, some of the target words (B) were repeated and some other targets were replaced with similar words (B') and the rest were replaced with totally different words (D), so the memorability of the target could be varied among the pair types. The results showed that TOTs as well as FOKs were directly related to cue familiarity but they were not related to target memorability.

Another inferential mechanism known as "the accessibility heuristic" was suggested by Koriat (1993). The accessibility heuristic states that when a target

cannot be recalled, the more target-related material that is recalled, the stronger the metamemory judgment. Schwartz and Smith (1997) examined the effect of the amount of information related to the target on subsequent recall and TOT rates using imaginary creatures called "TOTimals" as targets. Participants learned the names of imaginary creatures with different degrees of target related information. In the minimum information condition, participants learned only the cue-target pair (e.g., Panama-Yelkey). In the medium-information, and the maximum conditions, they were provided with such target related information as picture (medium condition) or picture and description (maximum condition) along with the country name and the imaginary creature's name. The medium and maximum information conditions resulted in more reported TOTs than the minimum information condition when participants were cued by country names at test. This result supports the accessibility heuristic because the more target-related material that subjects could recall for each TOTimal, the more TOT judgments subjects made.

There are other factors that can selectively influence metamemory judgments independently of target memory. Widner, Smith, and Graziano (1996) found that informing subjects that to-be-answered general knowledge questions would be easy to answer increased TOT reporting frequencies, presumably due to increasing social demand (or pressure) felt by the subject. Also, Schwartz (1998) demonstrated that subjects reported "illusory" TOTs for unanswerable questions (see also Schwartz, 2002; Schwartz, Travis, Castro & Smith, 2000).

It is clear that metamemory phenomena are governed by at least two types of mechanisms: first, in memory trace mechanisms, the system monitoring the contents of one's own memory bases metamemory judgments on the accessible partial memory traces of the target. Second, in inferential mechanisms, metamemory judgments are based on inferences, such as cue familiarity, amount of accessible target related information, and social pressure, rather than on the actual memory traces of the target.

Proposed Inferential Mechanism: Association Strength Heuristic

In the present study another potential metamemory mechanism called "the association strength heuristic" was investigated. The association strength heuristic predicts that TOT judgments will be based on the association strength between a cue and its associated target. Specifically, it is predicted that stronger associations between cues and targets will lead to stronger TOT reports and more frequent ones. This prediction holds true only for cases in which the cue-target strength is not sufficient for correct recall, as will be explained below.

When people try to recall a person's name cued by his/her photo, the person's name (target) may be known, and the photo (cue) may be very familiar to them, but they may not be able to match the photo with the name because the relationship between the cue and the target might not have been established. The degree of association between the photo and the target name is undoubtedly related to the frequency of cases in which people see the photo and the name occurring together, that is, the number of cue-target co-occurrences.

In the present study, it is assumed that the strengths of associations among cues and targets are distributed in the range from zero, or no association, to strong, that is, an association with sufficient strength for the target to be recalled. Furthermore, a change in the distribution of association strengths incurs corresponding behavioral outcomes, such as changes in the number of items recalled, the number of TOTs, and the number of non-TOTs.

Concerning the behavioral outcomes, varying the associative strength between the cue and target in a cue-target pair, independently of the memorability of the cue or the target, will have an effect on both TOT judgments and recall level. Particularly if the target memory fails to exceed the threshold for recall, increasing associative strength will not help participants recall the target *per se*, but it is still expected to increase the frequency or strength of TOT states. On the other hand, if the target memory strength is above or near the recall threshold, then strengthening the cue-target association will increase the number of items recalled while decreasing TOTs by resolving recall failures.

The association strength heuristic works very much like the cue familiarity heuristic or the accessibility heuristic. For example, in the familiarity heuristic, people assess the familiarity of the cue indirectly rather than assessing the memorability of the target itself directly, and they make TOT judgments based on their indirect and thus often incorrect assessments (Metcalfe et al, 1993). Likewise, in the association strength heuristic, people make TOT judgments based on their indirect assessment of association strength rather than direct

assessment of the target. Because one is not capable of calculating association strengths directly, one may use rules of thumb, or heuristics in assessing association strengths, and the perceived strength of the relationship between two discrete events may influence one's TOT reports.

The association strength heuristic, however, is qualitatively different from other known TOT heuristics described above. Because other heuristics, such as the familiarity heuristic, the accessibility heuristic, and demand characteristics can cause many spurious TOTs, they are not true memory phenomena, but they are solely metacognitive phenomena. By contrast, the association strength heuristic cannot be categorized solely as one or the other mechanism. The association strength heuristic is partly a true memory phenomenon because strengthening associations will increase veridical TOTs and also increase recall rates. On the other hand, it is also an inferential metamemory mechanism if people do not base their TOT judgments on the actual number of cue-target co-occurrences. That is, if people use their subjective judgments of association strength to determine their TOT strength, then such a heuristic would represent an inferential metamemory mechanism.

Present Study

In the present study, the association strength between cues and targets was experimentally manipulated and the effects of those manipulations on TOTs and correct recall were examined. In determining the best way to manipulate

cue-target association strengths, a number of methodological issues were considered.

Methodological Considerations: Preexisting Association Norms

An important question is how to manipulate associative strength without affecting cue or target memorability. There are several ways to manipulate association strength, according to the memory research literature. First, the most common and probably the easiest method is using pre-existing association norms. Association strength is usually defined by the frequency that a particular word is produced, given another word as the cue. The closeness or relatedness between the two words is one of the most important determining factors in forming the association. One of the most common ways to examine the effect of associative strength using this method is to compare learning performance among two or more groups of subjects as a function of associative strength. For example, Gallagher and Reid (1970) compared first and third grade non-retarded children and institutionalized retarded children, and found that overall error rates decreased as association strength increased. Performance of the retarded children was similar to that of the 3rd grade group for the highly associated pairs, but for weakly associated pairs the retarded group's performance was more like that of the 1st grade children.

Methodological Consideration 2: The Interference Paradigm

The second method utilizes the interference paradigm where A-B associations are weakened by A-C association processed later. In a typical A-B,

A-C paradigm, a stimulus word (A) is paired with two response words (B and C). Interference is assumed to occur because both B and C terms compete for the common stimulus term A, and the newly formed association blocks or dominates the old. This paradigm usually requires two groups, one experimental group and one control group. The experimental group learns the A-B list and then learns the A-C list. After a retention interval, this group is asked to recall the A-B list (to measure retroactive interference), or the A-C list (to measure proactive interference). The memory performance of the experimental group then is compared to that of the control group which did not learn the interfering list. For association strengths to be varied in this paradigm, subjects learn the A-B list in the first session and then learn the interfering pairs of different combinations between stimulus and response terms in the second session. Based on empirical studies, the relative sizes of interference and transfer effects each of the combinations has on the first list learning have been established (see Kjeldergaard,1968).

Methodological Consideration 3: Repeated Cue-Target Co-occurrences

The third method for controlling association strength is presenting the cue and target pair repeatedly, thus strengthening the relationship between two words. For example, Brosgole, Hanley, and Contino (1973) reported that exposing paired associates three times prior to test produced significantly better recall than a single exposure, with total time held constant.

All the methods for increasing associative strength considered so far, however, fail to manipulate the association strength between the cue and target separately from the memorability of the cue or the target, because changing association strength results in changes in cue and target memorability, as well. It is important to note that changing the duration, repetition, or intensity of cue and target exposure will strengthen not only the relationship between them, but it will also increase the item-specific memory for each cue or target (e.g., color, font, shape, etc.). To circumvent this problem, a method that makes it possible to vary the association strength between the cue and target without affecting either cue memorability or target memorability is required. In other words, association strength must be manipulated while independently controlling the degree of cue familiarity and target memorability.

One possible method is using co-occurrences of cues and targets. Studies have shown that related pairs of nouns co-occur significantly more often than unrelated pairs (e.g., Spence & Owens, 1990), and the associations are formed between two words that are contiguously processed. However, the duration of rehearsal and the amount of attention devoted to rehearsal does not appear to change the strength of associations (Bradley, & Glenberg, 1983). By varying the number of times that the cue and the target are presented together or separately in paired associate learning, one can manipulate not only the association strength, but also target memorability and cue familiarity, independently of each other.

TOTimals and Association Strength

The present study used imaginary creatures and their names, referred to as "TOTimals" in Smith, Brown, and Balfour (1991, 1994). In these studies, participants studied pictures of TOTimals along with their names, countries, diets, and sizes. Then they were asked later to recall the names, given the pictures or other information, such country names, as cues. Smith et al. (1991, 1994) found that TOTimals induced high levels of TOTs (over 30 %).

TOTimals are also very naturalistic stimuli because the pictures resemble existing animals, their names consist of one, two or three syllables that sound like real animal names and are easy to pronounce, and they belong to existing categories of animals (fish, insects, mammals, reptiles, birds, and amphibians; see Figure 1). TOTimals are especially appropriate for testing the predictions of the association strength heuristic because   there is no preexisting association between the cue and target, and it is easy to manipulate the frequency of presentations of cues,

Walgrinnit

Rodent   1'
Eats nuts   Bermuda

Perlimon

River fish   6"
Eats minnows   Amazon
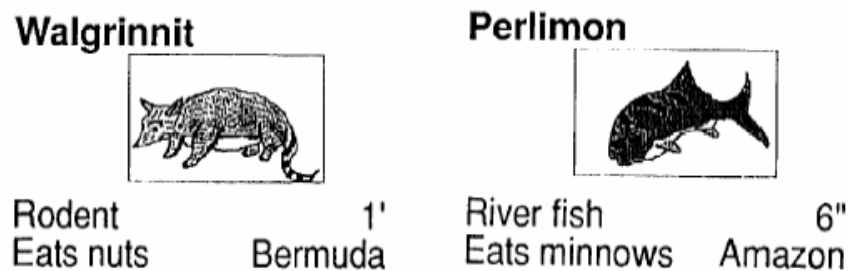
Figure1. Examples of TOTimals used in Smith et al.,1994

targets, and cue-target co-occurrences. In addition, considering proper names are the most common TOT targets in naturalistic studies (e.g., Schwartz, 2002), the TOTimal method suits the present study.

Smith et al. (1994) used the TOTimal method to examine the effect of practice on TOT judgments; practice writing target names, as compared with only reading them, improved recall performance and decreased TOT levels, but did not reduce Non-TOTs (NTOT). This pattern of results indicated that the practice on target names led to a "distribution shift" among recalled items, TOTs
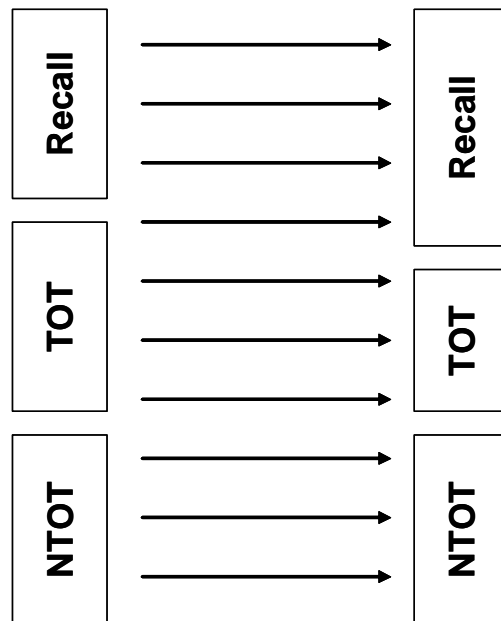
Figure 2. An illustration of distribution shift, adapted from Smith et al., 1994. Arrows indicate changes that occur due to practice. In Smith et al. (1994)'s study, it was suggested that writing target names strengthened visual-to-lexical connections, improving recall and decreasing TOTs, but not decreasing NTOTs.

and NTOTs. The result was interpreted as suggesting that practice writing the TOTimal names strengthened visual-to-lexical connections in memory that would have been deficient without the practice (see Figure 2).

The results obtained by Smith et al (1994)'s study are very typical. If target memorability is increased in an experiment, using such methods as practice, repetition, or level of processing, a distribution shift among recalled, TOTs, and NTOTs will occur, because some items that would have produced TOT responses without practice are recalled with practice, resulting in a decrease in TOTs. This type of manipulation not only increases target memorability but it also increases the association strength of the cue-target pairs. For example, varying the number of co-occurrences of the cue-target pairs among experimental conditions also increases the association strength between the cues and targets in addition to increasing target memorability and cue familiarity. If one wants to examine the effect of repeating cue-target pairs on TOTs or FOKs (feeling of knowing), an increase in the metamemory judgments may occur due to increased target memorability or cue familiarity, and it may occur possibly due to strengthened association. That is why in the present experiments, association strength was manipulated separately, controlling the degree of cue familiarity and target memorability. To achieve a dissociation between target memorability and association strength, all the cues and targets occurred the same number of times across all conditions, and only difference

among the conditions was the number of times when the cue and target co-occurred.

Even though presenting cues or targets alone before or after the formation of associations between them inevitably leads to slight changes in association strength, the amount of these changes due to the presentation order is expected to be negligible. In studies investigating the effect of cue or target familiarity, the familiarization session was usually held prior to the associative learning session with no particular justification of the order or a theoretical basis (Goss & Nodine,1965). Following convention, the individual cue or target was presented alone in the first part of the study phase, and the entire cue and target pairs were presented in the second part of the study phase in the present study.

Another methodological consideration concerns the type of encoding task. A variety of encoding methods have been utilized at learning trials in the study of paired associate learning for the purpose of familiarizing stimulus and response terms, including 'write down', 'say out loud', 'spell and recall', 'pronounce and rate for pronunceability', and 'generate,' etc. Because the role of encoding in the present study is to induce TOT states rather than to increase recall, it is sufficient to bring the target memory close to the threshold for recall, which allows the use of a less effective encoding method, such as simple visual presentation at a fixed rate.

The present study used imaginary creatures and their names, as used in Smith et al.'s (1991) study. To manipulate association strength, the number of

times when the picture and the name appeared together on the screen was varied across conditions (a within subject factor). However, the number of times when each individual picture or the name appeared on the screen, including when they appeared together, was equal for all conditions. Nevertheless, it was expected that recall rates would increase as the cue and target relationship became stronger because there is a body of research evidence that shows that increasing association strength in paired learning improves learning (e.g., Balch & Shapiro,1971; Chuang,1972; Gallagher & Reid, 1970). An overall high recall level not only gives few opportunities for TOT states, it also leads to resolution of many TOT states. Such a situation could lead to an erroneous conclusion that the greater the association strength, the fewer incidences of TOT states. In order to look at the effect of association strength alone, recall level needs to be controlled, keeping it at a low level. In the present study two experimental methods were used to control recall level. In Experiment 1, the overall recall level was reduced using interference, so those items that would have been recalled without interference would be blocked, thus increasing the frequency of TOT responses. In Experiment 2, the number of critical items was increased substantially, and the learning time was halved, making paired association learning quite demanding. To control recall level statistically, as well, the proportion of TOT cases out of total number of TOT opportunities (the total number of items minus the number of recalled items) was used as a dependent variable.

Predictions

The first and foremost prediction of the study is that when increasing cue-target association strength does not increase recall levels, then it will increase the frequency and reported strength of TOT states. For the association strength heuristic to make this prediction, the distribution of memory strengths of target material must be sufficiently below the threshold needed for accurate recall. If the memory strength of the target material is weak enough, then small increases in cue-target strength may not result in increased accurate recall. In such a case, increasing the association strength of weak memories should result in more TOTs without increasing recall levels. If the distribution of memory strengths of target material is too high, however, strengthening associations will boost participants' recall performance. Consequently, some items that would have induced TOT responses will be resolved as the association between the cue and target gets stronger, resulting in a decrease in both TOT frequency and strength. Therefore, analyses that test this prediction of the association strength heuristic will focus on cases in which increasing association strength does not increase recall levels.

Another important prediction is that judged number of co-occurrences of cue-target pairs should be correlated with the actual number of co-occurrences. Moreover, both actual number of co-occurrences and judged number of co-occurrences should be correlated with TOT strength. According to the association strength heuristic, TOT strength is indirectly related to actual number

of cue-target co-occurrences, but directly related to association strength. Association strength is imperfectly determined by the actual number of co-occurrences. Therefore it is possible that a stronger correlation will be found between judged number of co-occurrences and TOT strength than the correlation between the actual number of co-occurrences and TOT strength (see Figure 3).

Finally, it is predicted that judged number of co-occurrences for cue-target pairs will be correlated with spurious or false TOT strength. If people believe that cue-target pairs co-occurred many times, even if that belief is in error, people may report stronger TOTs, as compared to when they believe that pairs co-occurred just one time,
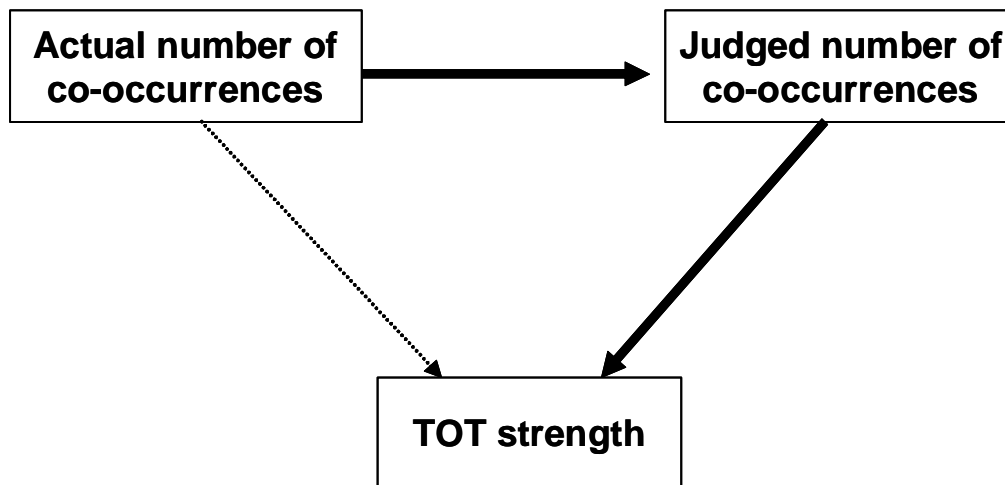
Figure 3. The predicted relationships among actual number of co-occurrences, judged number of co-occurrences, and TOT strength. The thickness of the arrows indicates the strength of the relationship.

People will be aware of the fact that they have seen the cue and the target together on the screen multiple times, and this automatically registered information will be (although implicitly) used when they make TOT judgments. One's estimation of the frequency information, however, is far from perfect; thus, many errors may occur when one tries to utilize this information in making TOT judgments, because one has to rely on an approximation of the number of co-occurrences. In other words, one relies on rules of thumb, or heuristics.

EXPERIMENT 1

Experiment 1 examined the effect of the number of repeated presentations of the cue and target pair shown together on TOT frequency and recall rates. In the control condition, subjects studied eight imaginary creatures and their names. Immediately after the study phase, subjects recalled the imaginary animals' names cued by their pictures. Subjects were also asked to report their TOT states if they were not able to write down the correct answers. In the interference condition, subjects studied the same picture and name pairs but additionally they studied 16 more pairs that were intended to reduce recall rates by interfering with the eight critical items.

The present study used graded TOTs by having subjects report their phenomenological experience of TOT on a scale ranging from zero to three. Even though most TOT studies use binary TOT judgments (e.g., "TOT" or "no TOT"), some studies use multiple levels of TOTs. Brown and McNeill (1966) made a distinction between a "nearer" TOT and a "farther" TOT. A TOT report was referred to as a nearer TOT when the target word was recalled during the TOT and a farther TOT when the target was not produced before it was given by the experimenter. Schwartz et al (2000) identified several dimensions of TOTs, such as imminent and non-imminent, emotional, non-emotional, strong and weak TOTs. Choi and Smith (in press), and Widener et al. (1996) also used a graded TOT measure ranging from zero to three to examine the relationship

between resolution and TOT strength. They found that resolution was greater for stronger TOTs.

Method

Participants

One hundred seventeen undergraduate student volunteers participated in the experiment. For one hour of participation, students received credit toward their research requirements in their introductory psychology courses.

Materials

Twenty-four imaginary creatures and their names were used (see Appendix 1). Each item consisted of cue-target pair in which a cue was a TOTimal picture and the target was a name. The eight critical items were divided into four 2-item sets. For each 2-item set, the cue-target pairs were presented together either once, twice, three times, or four times. Cue-target co-occurrences, a within subject variable, was counterbalanced between subjects (e.g., the two cue-target pairs were repeated once for one group, twice for a second group, three times for a third group, and four times for a fourth counterbalancing group). Thus, each cue-target pair was presented for each co-occurrence frequency, when counterbalanced across subjects.

TOTimals were presented on a large computer screen one at a time. A paper and pencil recognition test was administered at the end of the experiment. The recognition test consisted of eight multiple choice questions each with 4 choices. For each test item, a picture of one of the TOTimals was shown, and

the subject had to choose the correct name of the animal out of 4 alternative choices.

Design and Procedure

A 2 X 4 X 4 (interference X number of co-occurrences X counterbalancing) mixed factorial design was employed . There were two levels of interference, control vs. interference, a between-subjects variable. There were four levels of number of co-occurrences variable, 1, 2, 3, or 4 co-occurrences, a within-subjects variable. There were four different counterbalancings, a between-subjects variable, such that across four counterbalancing conditions each TOTimal item was presented with each number of co-occurrences. Participants were tested in groups. At the learning phase, participants were presented first with pictures or names alone, one at a time each for 4 seconds with a fixed random presentation order. Then participants were presented with each picture and name pair, either once, twice, three times, or four times. The total number of times each picture and name was presented was constant for all items. That is, regardless of number of cue-target co-occurrences, each TOTimal picture and each name was seen five times. For example, for TOTimals in which the cue-target pair co-occurred only once, the individual pictures and individual names were shown four times each. Likewise, when cue-target pairs co-occurred four times, the individual picture and name were seen only one time each (see Figure 4).
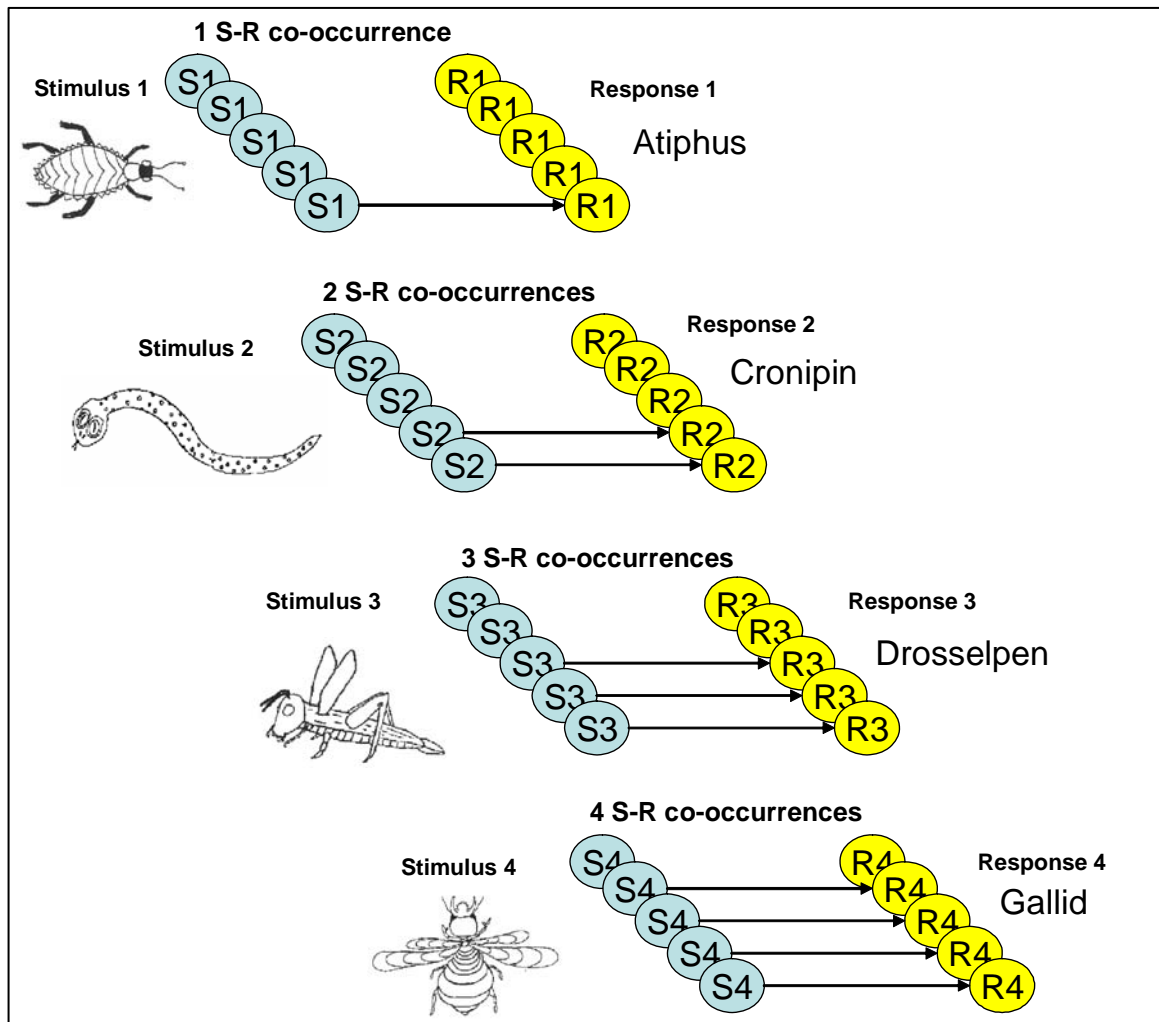
Figure 4. Stimulus examples and their presentation schema

Right after the learning phase, a cued recall test and TOT rating task was administered. Participants were given a response form (see appendix 2) and they were given the instructions for cued recall and TOT rating. Participants were shown the pictures of TOTimals one at a time for 40 seconds each. Each picture was signaled by a "ding" sound. Participants were told to either write each animal's name if they knew it, or rate their TOT state if they did not think of

the answer in the time allowed. The term "tip-of-the tongue state" was defined as

follows: "A tip-of-the tongue state is a state of mind in which you can't think of

the answer now, but you feel you know it, and it feels like it is going to pop into

your mind any moment." They were asked to rate their TOT states on a scale of

0 - 3, with "0" indicating no TOT and "3" the strongest TOT. Participants

indicated their choices by circling the appropriate numbers on the form. In

addition, when they could not think of the name, they were asked to write any

part of the name that they could. This was to see if they had any partial

knowledge of the target even when they could not recall the entire target. Finally,

participants also reported their subjective judgments of how many times each

picture-name pair had been shown together, that is, their judged number of cue-

target co-occurrences (see Figure 5).
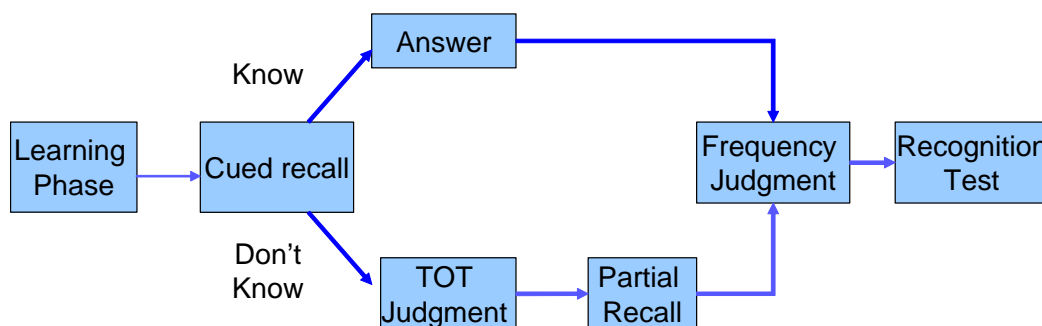
Figure 5. Experimental procedure used in all 3 experiments. After the learning phase, each item was tested on a cued recall test. Responses to each item depended on whether the item's name was known or not. In Experiments 2 and 3, there were two phases of the recognition test: the identification and matching tasks.

The answer forms were collected and the recognition test was administered. A recognition question consisted of a picture of an animal, and four possible answers: the target, two lures that were presented in the learning phase, and one new item that the subjects had never seen. The whole procedure lasted about 45 minutes.

Results

A significance level of *p < .05* was used on all statistical tests for all experiments reported, unless otherwise specified. Making a within-participant comparison of recovered and continuous memories resulted in dropping some participants because not everyone experienced all levels of TOT strengths. This was especially problematic in Experiment 1 because there were only 8 critical items. In comparison, 24 items were used in Experiments 2 and 3, increasing opportunities of observing TOTs of all strengths. Due to this limitation in the data in Experiment 1, all analyses in Experiments 1, were analyzed and reported by item, except for recall and recognition.

Veridical TOTs

A TOT response was categorized as veridical if the participant correctly recognized the target on the recognition task. A 2 (interference) X 4 (number of co-occurrences) analysis of variance (ANOVA) was conducted on the proportion of TOT states out of the total number of TOT opportunities averaged by each item (i.e., number of TOT responses divided by the total number of items, minus the number of recalled items for each imaginary animal). There was only a

marginal main effect of number of co-occurrences [$F(3,21) = 2.82$, $MSE = 0.03$, $p = 0.06$]. A post hoc trend analysis showed that the quadratic component of the total variance was significant ($p = 0.01$). The quadratic component indicated that TOT frequency was equivalent for one, two, and three co-occurrences, whereas it dropped at the four co-occurrence condition, presumably due to the high level of recall in that condition (see Table 1).

TABLE 1

Mean proportions of veridical and spurious TOTs by actual number of co-occurrences and interference condition in Experiment 1

	Number of Co-occurrences							
	One		Two		Three		Four	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Veridical TOTs								
Interference	0.35	0.07	0.47	0.06	0.58	0.04	0.48	0.09
Control	0.42	0.07	0.42	0.07	0.56	0.05	0.45	0.11
Spurious TOTs								
Interference	0.36	0.07	0.26	0.07	0.27	0.05	0.18	0.08
Control	0.12	0.04	0.15	0.07	0.04	0.02	0.19	0.09

A 2 (interference) X 3 (number of co-occurrences) ANOVA was computed with TOT frequency as the dependent measure, using only the first three co-occurrence conditions. Because recall was equivalent in those three conditions, a comparison that is limited to those conditions provides a clear test of the

association strength heuristic. This analysis revealed a significant effect of number of co-occurrences [$F(2,14) = 10.18$, $MSE = 0.01$]; The greater the number of co-occurrences, the greater the frequency of TOTs.

TABLE 2

Mean strength of veridical TOTs by actual number of co-occurrences and interference condition in Experiment 1

	Number of Co-occurrences							
	One		Two		Three		Four	
Condition	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Interference	0.71	0.15	1.49	0.14	1.91	0.09	1.88	0.29
Control	0.46	0.12	1.11	0.08	1.36	0.27	1.38	0.30

A similar 2 X 3 ANOVA for average TOT strength produced a marginal effect of number of co-occurrences [$F(2,14) = 10.18$, $MSE = 0.01$]; the greater the number of co-occurrences, the higher the TOT strength. In addition, the effect of interference was significant [$F(2, 7) = 16.18$, $MSE = 0.21$]. Generally, people in the interference condition reported stronger TOTs than those in the control condition (see Table 2).

A comparable ANOVA also for the three levels using total number of TOT items instead of using the proportion of TOT items among the unrecalled items as the dependent measure was performed. There was a significant main effect of interference [$F(2,156) = 6.05$, $MSE = 0.71$], and a marginal interaction effect

between interference and number of co-occurrences [$F(2,156) = 6.05$, *MSE* = 0.70, *p* = 0.11]. More TOTs were reported in the interference condition than in the control condition and a marginal simple main effect of number of co-occurrences was found only for the interference condition [$F(2,156) = 2.51$, *MSE* = 0.71, *p* = 0.09].

    Spurious TOTs

A 2 (interference) X 4 (number of co-occurrences) ANOVA was conducted on the proportion of spurious TOTs, that is, TOTs that participants failed to recognize on the four choice recognition test administered at the end of the experiment. There was no effect of number of co-occurrences on number of spurious TOTs. The effect of interference on spurious TOTs was significant [$F(1, 7) = 8.60$, *SE* = 0.04]. Participants in the interference condition (*M* = 0.27, *SE* = 0.05) reported significantly more TOTs than participants in the control condition (*M* = 0.12, *SE* = 0.03).

Pearson's correlation coefficients were computed to compare the relationships among the strength of false TOTs, actual number of co-occurrences, and judged number of co-occurrences. For spurious TOTs, there was no correlation either between judged number of co-occurrences and actual number of co-occurrences, or between TOT strengthand actual number of co-occurrences. Between judged number of co-occurrences and spurious TOT strength, however, a significant positive correlation was found (*r* = 0.32).

Recall

A 2 (interference) X 4 (number of co-occurrences) ANOVA was computed

with the proportion of correctly recalled items as the dependent variable. There

were significant main effects of interference [$F(1, 83) = 23.72$, *MSE* = 0.07];

Participants in the control condition recalled significantly more items that those in

the interference condition and number of co-occurrences [$F(3, 249) = 12.30$,

MSE = 0.09]. The more the number of co-occurrences, the more items

participants recalled. These main effects were qualified by a interference X

number of co-occurrences interaction [$F(3, 249) = 4.00$, *MSE* = 0.09]. Simple

main effects analyses looking at the effect of number of co-occurrences

separately for each interference condition revealed that both of the simple main

effects were significant. Planned comparisons among the 4 levels of co-

occurrences showed that the mean of the four co-occurrence condition (*M* =

0.40) was significantly greater than the means of the other three conditions, and

there were no differences among the other three co-occurrence conditions (*M*s =

0.26, 0.26, 0.25, respectively) when there was interference. The effect of

number of co-occurrences was much greater for the control condition [$F(3,102)$

$= 10.24$, *MSE* = 0.10] than for the interference condition [$F(3, 147) = 3.22$, *MSE*

= 0.08]. The results indicate that the difference in recall between the interference

and control conditions became progressively greater as the number of co-

occurrences increased for both interference and control conditions.

Figure 6 shows the proportions of correct recall as a function of number of co-occurrences. Note that the recall levels did not change much up to three co-occurrences in the interference condition. However, the recall for the control condition continued to increase from 38% (one co-occurrence) to 78% (four co-occurrences).
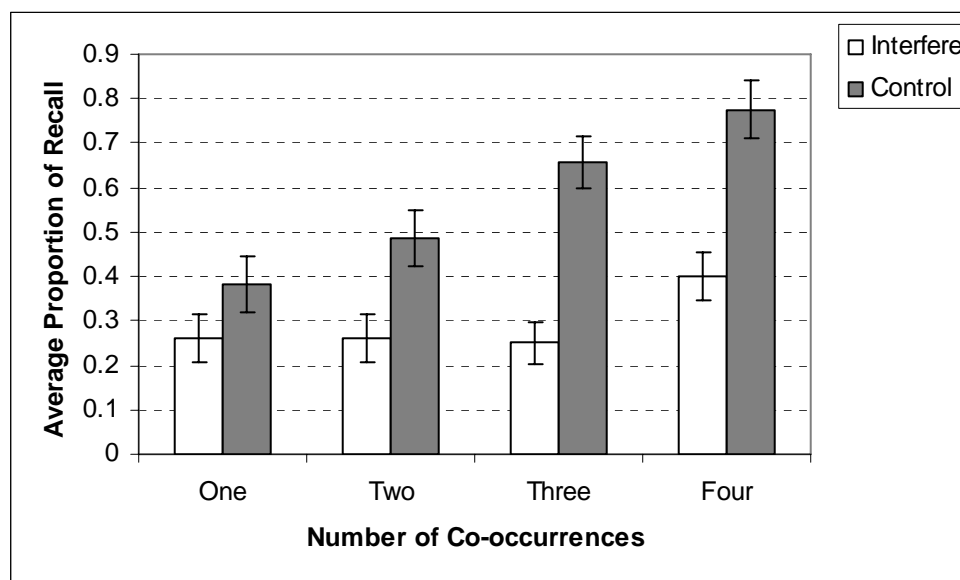
Figure 6. Average proportion of correctly recalled items as a function of number of co-occurrences in Experiment 1

Recognition

A 2 (Interference) X 4 (number of co-occurrences) ANOVA on proportion of correct recognition revealed very similar results as were found for recall (see Figure 7). That is, there was a significant main effect of interference [$F(3, 345)$ = 6.15, MSE = 0.12]. Participants in the control condition correctly recognized more of the critical items than participants in the interference condition. There

also was a significant main effect of number of co-occurrences on recognition [$F(1, 115) = 4.92$, $MSE = 0.12$]; however, the proportion of correctly recognized items dropped in the four co-occurrence/control condition, possibly because recognition reached the ceiling at three co-occurrences in that condition ($M = 0.89$, $SE = 0.03$). The interaction between the two variables was only marginal ($p = 0.09$).
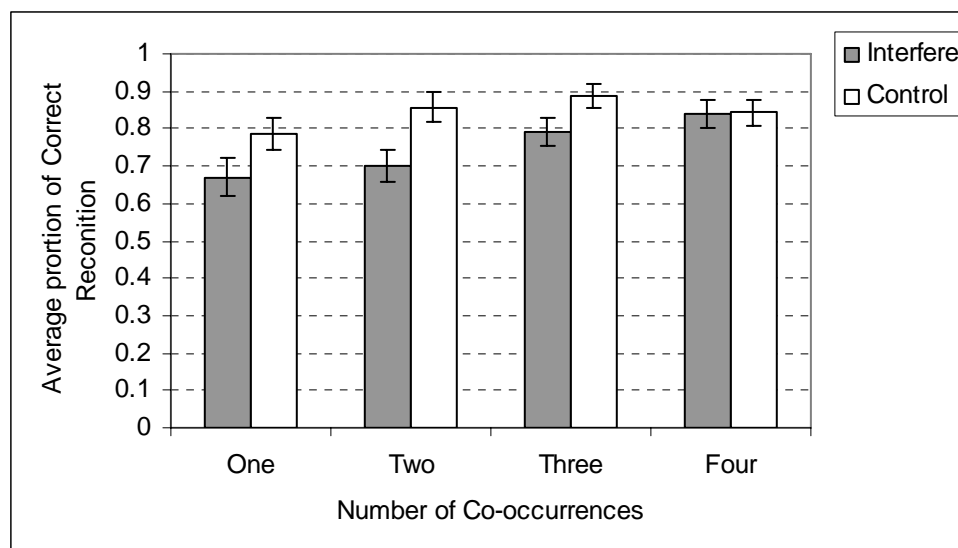
Figure 7: Average proportion of correctly recognized items as a function of number of co-occurrences in Experiment 1

Partial Recall

TABLE 3

Mean proportion of correct partial recall by interference and number of co-occurrences in Experiment 1

	Number of Co-occurrences							
	One		Two		Three		Four	
Condition	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Interference	0.22	0.04	0.27	0.04	0.27	0.06	0.38	0.13
Control	0.18	0.07	0.25	0.05	0.41	0.04	0.37	0.09

Participants reported partial information about the target for approximately 40% of the unrecalled items, and an average of 72.5 % of the partial information was correct. In the control condition partial recall was almost always correct (95%), whereas in the interference condition partial recall was correct only 62% of the time. In addition, the effect of number of co-occurrences was observed only in the interference condition. An 2 (interference vs. control) X 4 (number of co-occurrences) ANOVA with the four levels of co-occurrences as the independent variable on mean proportion of correct partial recall was computed to compare with the analysis conducted on correct recall. Even though there was no significant effect obtained, the pattern of the results was very similar to the previous analysis on recall (see Table 3).

Actual vs. Judged Number of Co-occurrences

In all of the analyses reported so far, the actual number of co-occurrences of cue-target pairs was used. An additional series of ANOVAs was conducted using the same TOT measures to compare the TOT reports as a function of actual number of co-occurrences versus TOTs as a function of participants' judged number of co-occurrences. Overall, the results were consistent with the previous analyses that used the number of actual co-occurrences as the independent factor. If anything, the effects using judged number of co-occurrences were even greater than those seen in the previous. A 2 (interference) X 4 (judged co-occurrences) ANOVA using TOT frequency as the dependent variable revealed a significant main effect of judged number of co-occurrences [$F(3,15) = 3.31$, $MSE = 0.04$]; The greater the average number of judged co-occurrences, the more TOTs were reported. Furthermore, when only the first three levels were considered, there was also a significant main effect of interference [$F(2, 14) = 10,82$, $MSE = 0.26$]; more TOTs were reported in the interference condition than in the control condition. The same analyses using the effect of judged co-occurrences on TOT strength produced very similar results; the main effects of both interference and judged number of co-occurrences were significant [$F(1, 7) = 21.04$, $MSE = 0.10$; $F(1, 14) = 10.81$, $MSE = 0.26$, respectively]; participants in the interference condition reported stronger TOTs than participants in the control condition; TOT strengths linearly increased as a function of number of judged co-occurrences.

The relationships among TOT strength, the actual number of co-occurrences and the judged number of co-occurrences were examined using correlation analyses (see Figure 8). Pearson's correlation coefficients between actual number of repetition and judged number of repetition, between TOT strength and actual number of co-occurrences, and TOT strength and judged number of co-occurrences were all significantly greater than 0 ($rs = 0.29, 0.11$, and 0.25 respectively). More importantly, a stronger relationship was found between the judged number of co-occurrence and TOT strength than between the actual number of co-occurrences. Furthermore, the two correlations were significantly different from each other ($t = -2.30$, $p < 0.05$, two-tailed).
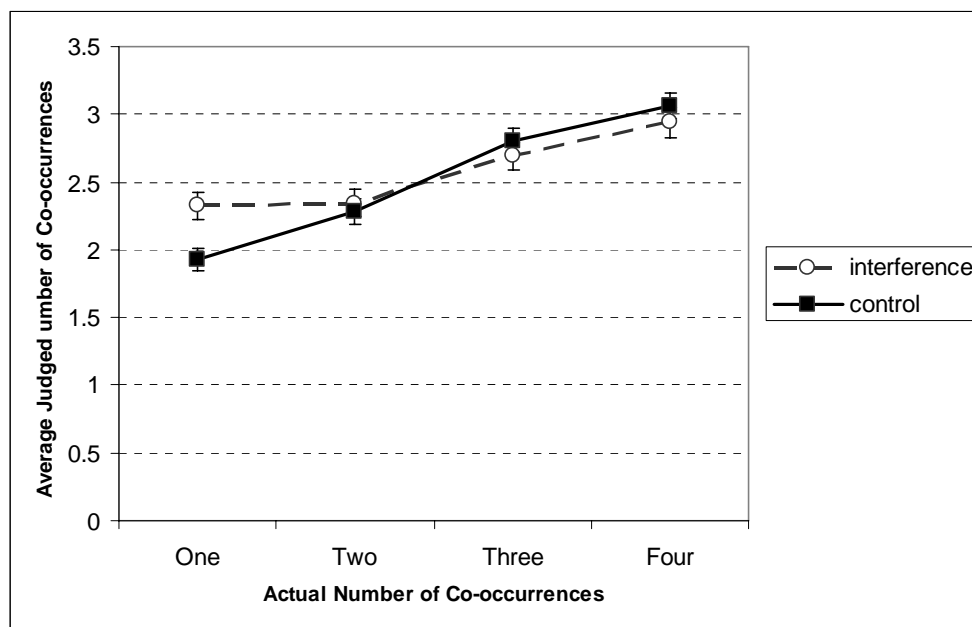
Figure 8. The relationship between actual number of co-occurrences and judged number of co-occurrences in Experiment 1

Finally, the relationship between the actual number of co-occurrences and the judged number of co-occurrences was also examined by a 2 (interference) X 4 (number of co-occurrences) ANOVA, using the average judged number of co-occurrences as the dependent variable. The main effect of number of co-occurrences was significant [F(3, 342) = 45.128 , MSE = 0.399], indicating that the greater the actual number of co-occurrences, the greater the judged number of co-occurrences. The interaction between interference and number of co-occurrences was also significant [F(3, 342) = 4.23 , MSE = 0.40]. Simple main effect analyses for each level of interference showed that the effects of number of co-occurrences were significant for both conditions but the effect for the control condition was much greater than the interference condition. Overall, the average judged number of co-occurrences linearly increased as the number of actual co-occurrence increased; however, the participants' perception of co-occurrence frequency tended to regress toward the mean especially for the two extreme co-occurrence conditions (one and four co-occurrence conditions); that is, people overestimated one co-occurrence and underestimated four co-occurrences in their number of co-occurrence judgment.

Discussion

Most of the experimental predictions were supported by the results; reported TOT frequency and strength were increased as the number of cue-target co-occurrences was incremented. When there were four cue-target co-

occurrences, recall significantly increased. Therefore, the effect was limited to the first three levels of co-occurrences.

The predictions concerning judged number of co-occurrences were all confirmed by the results as well. The correlation between actual number of co-occurrences and judged number of co-occurrences was significant, and both actual number of co-occurrences and judged number of co-occurrences were correlated with TOT strength. Judged number of co-occurrences was more strongly correlated with TOT strength than was actual number of co-occurrences.

Why did an increase in association strength concomitantly increase the number and strength of TOT states? The Experiment 1 result clearly indicated that the number of times people saw the pictures of imaginary animals and their names on the same screen was an important predictor of both the frequency and the strength of their subjective TOT experiences. Apparently, the participants utilized the information on the number of co-occurrences when they were making TOT judgments. This possibility is supported by the Expreriment 1 result showing that the correlation between the judged number of co-occurrences and TOT strength was even greater than the correlation between the actual number of co-occurrences and TOT strength. Furthermore, a greater effect of number of co-occurrences was found with the ANOVA using the judged number of co-occurrences as the independent variable than with the ANOVA using the actual number of co-occurrences. It does not appear that participants

made TOT judgments solely based on the true memory traces. Subjects' TOT judgments were guided by their subjective feeling of how many times they encountered the cue and the target together. There was a puzzling significant but relatively weak correlation between the judged frequency and the actual frequency of cue-target repetitions in Experiment 1. Reder and Schunn (1996) suggest that frequency information is automatically encoded and implicitly used in many tasks, but attempting to verbalize or make conscious one's mental processes interferes with the task at hand. Participants in the present study probably implicitly used the frequency information registered at the study phase. When asked to report the frequency information explicitly in the present study, participants did not do very well because making the unconscious process conscious may have interfered with the task.

In Experiment 1, interference was used to keep recall level low, so that the subject had more TOT opportunities. People in the control condition performed better on all memory measurements including the recall, partial recall and recognition tests than those in the interference condition. As for TOTs, however, participants in the interference condition experienced more and stronger TOTs than did participants in the control condition. These results might be explained by the blocking theory of TOTs which states that TOTs can occur when plausible but incorrect words block the retrieval of the target word. It is possible that the increased TOTs observed in the interference condition were

incurred because the interference condition had 16 more items that might have come to the subject's mind in lieu of the true target.

Although manipulations of the number of cue-target co-occurrences affected TOTs, unlike the interference manipulation, they did not result in an inverse relationship between TOTs and recall. That is, recall increased as the number of cue and target co-occurrences incremented (at least up to three times). The fact that these two variables, interference and number of co-occurrences, led to different patterns of TOT and recall, indicates that the two factors influence different mechanisms that can cause TOTs. That is, whereas interference can increase TOTs by causing a blocking effect, increasing cue-target co-occurrences increases TOTs via the association strength heuristic.

The increase in recall as a function of number of co-occurrences found in this experiment appears to be a byproduct of having increased association strength. There are at least two possibilities as to why stronger associations might lead to better target recall. On the one hand, encoding may have been facilitated by increased numbers of co-occurrences during the learning phase. On the other hand, it is also possible that the target was retrieved better during the retrieval phase because the stronger association allowed the rememberer to have faster access to the target. Because subjects in every condition saw each target the same number of times, the item-specific memory for any target presumably was not different among all conditions. An increase in recall may affect the proportion of TOTs experienced in at least two ways. First, increasing

recall reduces TOT opportunities for the subject. That is, as people recall more items, they have fewer TOT opportunities. Second, a recall increase not only reduces TOT opportunities, it actually eliminates TOT states by resolving them. Studies have shown that TOTs are reliable predictors of resolution (Burke, MacKay, Worthley, & Wade, 1991; James & Burke, 2000; Read & Bruce, 1982; Schwartz, 1998, 2002; Smith, 1994). In addition, both experimental studies (e.g., Schwartz et al., 2000) and studies that used naturally occurring TOTs found greater resolution rates for TOTs that are judged to be "strong" or "imminent" than for those that are judged to be "weak" or "non-imminent" (Schwartz, 1999). Even though the results of Experiment 1 supported most of the experimental predictions, there were some problems in Exeriment1. First, because only 8 critical items (2 items for each condition) were used in Experiment 1, if participants did not experience any TOTs, the data could not be used for parametric inferential statistics. Thus, any participant who did not experience all levels of co-occurrences would be excluded from the analyses when a repeated ANOVA was used.

Second, the recognition test (4 multiple choice question), which was used as a criterion for determining whether TOTs were veridical or spurious, appeared to be too easy. Because among the three lures in each recognition question, only two were previously presented TOTimal names, participants could have guessed the target easily once they were able to identify the ones they had already seen. Once familiar items were selected as candidates for the target,

and unfamiliar items were dismissed as non-targets, the probability that participants could correctly guess among the four choices became greater. Consequently, a ceiling effect was observed on the recognition test in Experiment 1. It is very probable, therefore, that many of TOT reports regarded as true TOTs may have been, in fact, spurious TOTs.

Finally, the recall level observed in Experiment 1 was too high; as explained above in detail, a high recall rate not only reduces TOT opportunities, but it also eliminates TOT responses by resolving potential TOTs. Due to these problems, one cannot conclusively state that an increase in association strength also increases TOTs. These problems were corrected in Experiment 2.

EXPERIMENT 2

In Experiment 1, interference was used to keep the number of items recalled relatively low, so that the effect of association strength on TOTs could be more pronounced. In Experiment 2, low recall levels were achieved by substantially increasing the number of critical items (i.e., from 8 in Experiment 1 to 24 in Experiment 2). There are some advantages of using an increased number of critical items to reduce overall recall levels. With more critical items in Experiments 2 and 3, participants had more critical items for each co-occurrence condition, so participants were more likely to experience at least one TOT per each condition. This made it possible to use parametric inferential statistics in analyzing the data of Experiments 2 and 3, which could not be done for some of the data obtained in Experiment 1.

In addition to increasing the number of critical items in Experiment 2, the duration of the cue-target presentation was reduced to 2 seconds. The purpose of shortening the presentation duration was to achieve a further reduction in recall rates, and also to prevent a rapid increase in association strength as the number of co-occurrences was increased. According to the SAM (Search of Associative Memory) model (Raiijmaker & Shiffrin, 1981), the strength of an association is a function of the duration of contiguous experience. If true, presenting cue-target pairs at a faster rate will reduce overall association strength as well as recall level.

Another important change made in Experiment 2 was employing a much more rigorous recognition test to amend the problem of the ceiling effect observed in Experiment 1. A two-phase recognition test was designed to test the memorability of the target and to see if increasing the number of co-occurrences truly led to an increase in association strength. Predictions concerning TOTs, recall, and judged number of co-occurrences were similar to the first experiment. It was predicted that there would be a significant effect of the number of cue-target co-occurrences on the frequency and strength of TOTs. Both the number of actual and judged co-occurrences was predicted to be correlated with TOT strength. It was also predicted that a stronger correlation would be found between the judged number of co-occurrences and TOT strength than between the actual number of co-occurrences and TOT strength.

It was also predicted that there would be a dissociation between performance in the identification part of the recognition test and performance in the matching part of the test. That is, the number of co-occurrences was not predicted to affect the number of correctly identified items on the recognition test, whereas it was predicted to affect the number of correctly matched items on that test. These predictions are based on the idea that matching a TOTimal picture with its name should depend on the cue-target association strength, whereas identifying the correct spelling of a TOTimal name should not. Identification should depend merely on the number of times the name has been seen, which was constant across all conditions.

Method

Participants

Fifty four undergraduate student volunteers participated in the experiment. Students received credit toward their research requirements in their introductory psychology courses.

Materials

The materials were the same as those used in the first experiment, but the number of critical items was tripled, using all 24 imaginary creatures as critical items (see appendix 1), including the ones used for filler items in the interference condition of Experiment 1. The twenty four items were divided into 4 groups of 6 TOTimals each. All six cue-target pairs in a group were given the same number of co-occurrences for a given counterbalancing. As in Experiment 1, the cue-target pairs co-occurred either one, two, three, or four times. The number of co-occurrences of items was counterbalanced between subjects. During presentation, items were shown for 2 seconds each. Another important change from the first experiment was made in the recognition test. The recognition test in Experiments 2 and 3 consisted of two parts. In the first part, participants were tested for the memorability of the target. In this phase of the recognition test, participants saw a page with 150 names. Twenty four of the names were the correct spellings of the items they studied. The twenty six distracters were composed of parts of correct names that were incorrectly combined. They were asked to circle all of the correct names on the page. This

was done to test target memorability, independent of cue-target association strength (see appendix 3). The second part of the recognition memory test was a matching test. For this, an additional sheet of paper that contained all the pictures of the imaginary creatures participants studied at the beginning of the experiment was given to participants. Each picture was numbered from 1 to 24. Participants were asked to match pictures with names, writing the matching numbers on the spaces next to the names they circled in the first part of the recognition test. Participants were also asked to write the appropriate number of TOTimals if they found more items they had seen in the study phase, even if they failed to identify names in the first phase of the recognition test (see appendix 4).

Design and Procedure

A 4 X 4 (number of co-occurrences X counterbalancing) factorial design was employed. There were four levels of number of co-occurrences variable, either 1, 2, 3, or 4 co-occurrences, a within-subjects variable. And there were four different counterbalancings, a between-subjects variable. The procedure was very similar to that in Experiment 1. The procedure consisted of study phase, recall or TOT judgments, subjective judgments on number of co-occurrences and the two phases of recognition test at the end of the experiment.

Results

Most analyses in Experiment 2 used one-way ANOVA with four levels of number of co-occurrences. The procedure was the same as Experiment 1.Now

that there were 6 critical items for each co-occurrence conditions, all the TOT

measures could be averaged by per condition for each subject. Therefore, all

analyses were done by subjects in Experiments 2.

Veridical TOTS

TABLE 4

Mean proportion of recall and TOT frequency and TOT strength by
number of co-occurrences in Experiment 2

	Number of Co-occurrences							
	One		Two		Three		Four	
	M	SE	M	SE	M	SE	M	SE
Recall	0.08	0.02	0.13	0.02	0.14	0.03	0.21	0.03
Partial Recall	0.12	0.02	0.15	0.02	0.23	0.03	0.28	0.04
TOT frequency	0.15	0.03	0.23	0.03	0.30	0.04	0.38	0.04
TOT Strength	1.20	0.08	1.51	0.09	1.60	0.09	1.72	0.11

Average TOT frequency and strength by number of co-ccurrences in

Experiment 2 are shown in Table 4. A one-way ANOVA using the proportion of

TOTs as the dependant variable revealed a significant effect of number of co-

occurrences [$F(3, 150) = 11.17$, $MSE = 0.04$]. The frequency of TOT reports

continued to increase as the number of co-occurrences was incremented from

one co-occurrence to four co-occurrences. Unlike in Experiment 1, TOT

frequency did not drop at the four co-occurrence condition; the fourth condition, in fact, produced the biggest increase in number of TOT reports. This result is remarkable considering the fourth condition also produced the greatest increase in recall. A separate ANOVA performed on average TOT strength also indicated that participants reported stronger TOTs for the items with greater association strengths [$F(3, 150) = 9.65$, $MSE = 0.26$]. ANOVAs on any of the TOT measures, such as proportion of TOTs out of unrecalled items, or out of total items yielded a significant effect of number of co-occurrences.

Spurious TOTs

TABLE 5

Average spurious TOT frequency and strength by number of actual and judged co-occurrences in Experiment 2

	Number of Co-occurrences							
	One		Two		Three		Four	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Actual								
Frequency	0.54	0.04	0.51	0.04	0.47	0.04	0.42	0.04
Strength	1.20	0.08	1.51	0.09	1.60	0.09	1.72	0.11
Judged								
Frequency	0.25	0.05	0.46	0.05	0.50	0.04	0.50	0.08
Strength	1.55	0.21	1.65	0.17	1.95	0.20	2.27	0.23

A TOT response whose target the subject failed to match on the matching test was categorized as a spurious TOT. Overall, a greater proportion of unrecalled items induced spurious TOTs (M = 0.26, SE = 0.02) than veridical TOTs (M = 0.484, SE = 0.03). Whereas veridical TOT frequency increased as a function of number of co-occurrences, spurious TOT frequency decreased as the same function, as revealed by an ANOVA [$F(3, 150)$ = 2.88, MSE = 0.05]. Notably, TOT strengths did not show a clear pattern across the actual co-occurrence conditions. However, they clearly increased across the co-occurrence conditions when the judged number of co-occurrences was used as the independent variable (see Table 5). Correlation analyses indicated that a significant positive correlation was found only for the judged number of co-occurrences (r = 0.24).

Recall

The means and standard errors are shown in Table 4. As expected, much smaller proportion of items were recalled in all conditions in comparison with the level of recall observed in Experiment 1 (total M = 0.14). One way ANOVA was computed to compare the proportions of correct recall among the four co-occurrence conditions. Consistent with the Experiment 1 result, the proportion of correct recall increased linearly as a function of the number of co-occurrences [$F(3, 159)$ = 8.25 , MSE = 0.02]. Pair-wise comparisons among the means showed that recall rate of the 4 co-occurrence condition was greater than the rest 3 conditions and among the rest of comparisons, the only significant mean

difference was found between the three co-occurrences and one co-occurrence conditions.

Partial Recall

Participants reported partial information about the target approximately 22% of the unrecalled items and an average 70 % of the partial information was correct. An ANOVA with the four levels of co-occurrences as the independent variable performed on the mean proportion of correct partial recall revealed a significant effect of number of co-occurrences [$F(3, 150) = 7.47$, *MSE* = 0.04], indicating that participants' partial knowledge about the target was more accurate as a function of number of co-occurrences. The pair-wise comparisons among the means showed that the last two co-occurrence conditions resulted in more accurate partial information than both of the first two co-occurrence conditions but the comparisons between the first two or the last two were not significantly different.

Actual and Judged Co-occurrences

The relationship between actual vs. judged co-occurrences was further examined by a one way ANOVA with the judged number of co-occurrences as the predicted variable and number of actual co-occurrences as the predictor variable (see Figure 9). There was a significant effect of number of actual co-occurrences [$F(3,159) = 6.40$, *MSE* = 0.17] even though the effect size ($\eta^2 = 0.11$) was much smaller than that of Experiment1 ($\eta^2 = 0.28$). Pearson's correlation coefficients computed between actual number of co-occurrences and

judged number of co-occurrences, between TOT strength and actual number of

co-occurrences, and between TOT strength and judged number of co-

occurrences were all significant (rs = 0.14, 0.07, and 0.43 respectively).
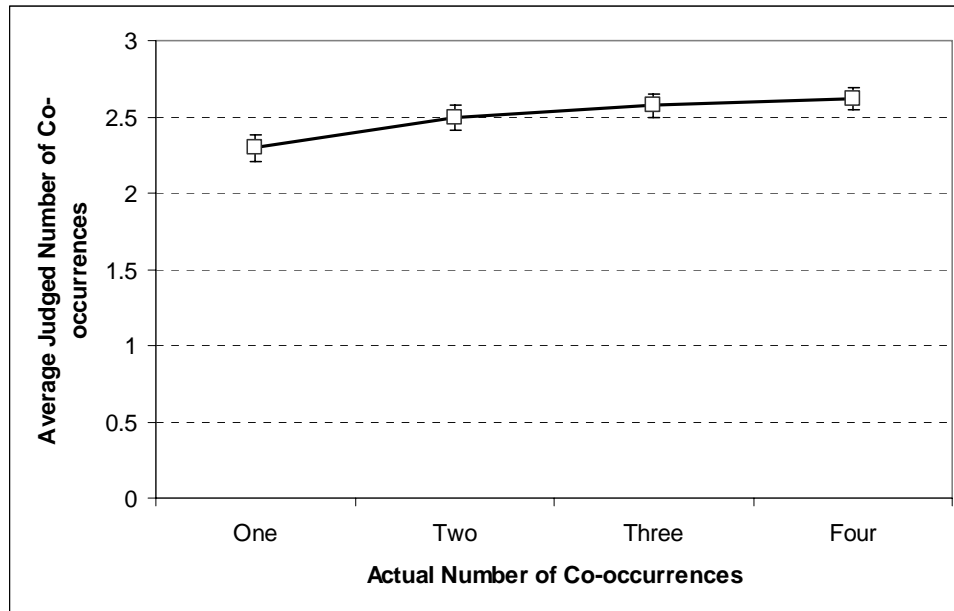
Figure 9. Average judged number of co-occurrences as a function of
actual number of co-occurrences in Experiment 2

Consistent with the Experiment 1 result, a stronger relationship was found

between the judged number of co-occurrences and TOT strength than between

the actual number of co-occurrences and the two correlations were significantly

different from each other (t = -6.02, p < 0.001, two-tailed) as well (see Figure
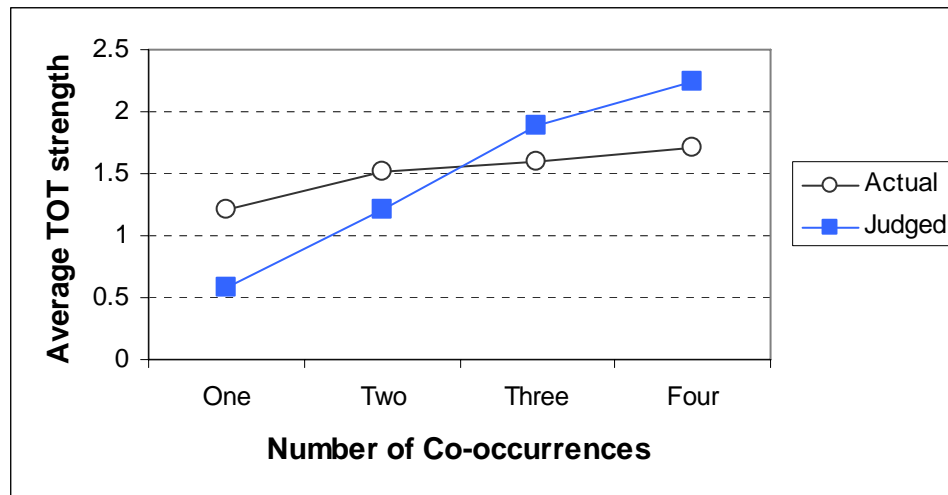
10).

Figure 10. Average TOT strength as a function of actual and judged number of co-occurrences in Experiment 2

Identification and Matching

Figure 10 shows the proportion of correctly matched and identified as a function of number of co-occurrences. Mean percentage of matched items among the unrecalled items was 34.6% whereas mean percentage of identified was 50%. Two separate ANOVAs were computed to examine the effect of number of co-occurrences on people's abilities to correctly match and identify the studied items in the recognition test. Greater number of co-occurrences yielded greater number of correctly matched pairs [$F(3, 159) = 17.01$, $MSE = 0.04$] but the number of correctly identified cue-target pairs did not differ as a function of number of co-occurrences [$F(3, 159) = 0.35$, $MSE = 0.04$]. As you can see in the figure 11, matching is selectively affected by the manipulation. The proportion of correctly identified items did not increase (even slightly declined) as a function of number of cue and target co-occurrences.
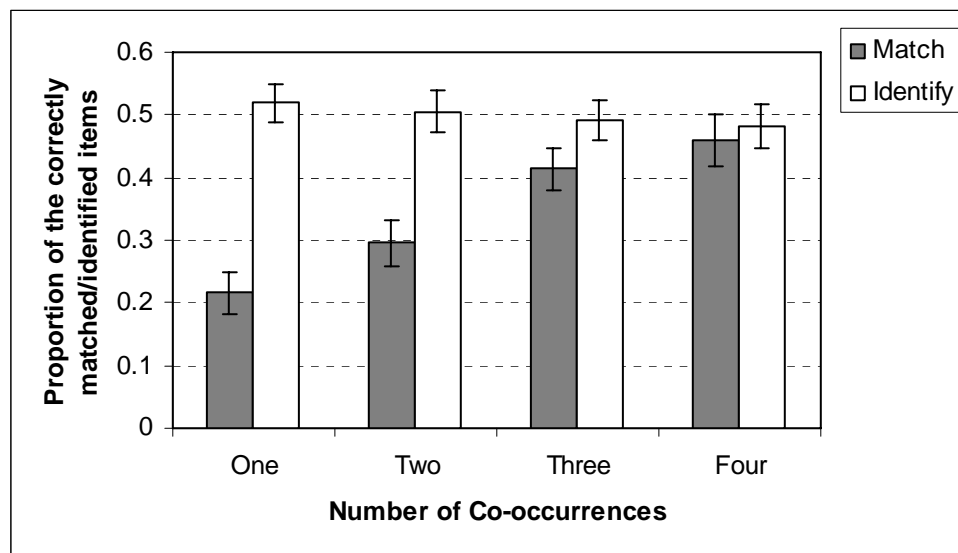
Figure 11: proportion of correctly matched and identified items as a function of number of cue and target co-occurrences in Experiment 2

Discussion

The experimental predictions were fully supported by the results of Experiment 2. As predicted, TOT frequency and strength increased as the number of co-occurrences was incremented. This effect was observed even when the rate of recall increased in the four co-occurrence condition.

Using a stringent criterion for discriminating veridical TOTs from spurious TOTs did not affect the key findings in the experiment. It is important to note that judging from the low level of target recall, learning for the majority of the items may have been incomplete, and yet participants reported a high proportion of TOTs. In both typical laboratory and naturalistic studies (Koriat & Lieblich, 1974,1975; Kozlowski, 1977), TOTs occur on approximately 10 -15% of retrieval

attempts. In Experiment 2 of the present study, by contrast, the proportion of TOTs out of all recall attempts was as high as 60%. These results cannot be explained solely by accounts that attribute TOTs to true memory phenomena because the low levels of memory performance indicate that encoding was less than complete. In this regard, it is also important to note that the analyses of TOT strength yielded a greater relationship between judged number of co-occurrences (relative to actual number of co-occurrences) and TOT strength for veridical TOTs. Furthermore, the pattern of the results in Experiment 2 for the spurious TOTs was comparable to the findings with veridical TOTs. It seems clear that association strength affected participants' judgments for both veridical and spurious TOTs.

Another interesting finding in Experiment 2 was a dissociation between matching and identification on the recognition test. Many of the correctly identified names were not correctly matched, whereas many of the correctly matched items also were not identified. Only the proportion of correctly matched items differed as a function of the number of co-occurrences. In addition, the stronger the TOT, the more items among the unrecalled items were matched. However, this was not true for the number of correctly identified items. In other words, a strong TOT did not necessarily lead to successful identification of the item. This result indicates that one's ability to match a cue to a target is a better predictor of TOT strength (possibly TOT frequency as well) than one's ability to identify the target.

In Experiment 2, however, the correlation between judged and actual number of co-occurrences was rather weak (r = 0.067) in comparison to that in Experiment 1 (r = 0.284). The weak correlation was probably due to the increase in number of critical items and the briefer presentation times. Participants in Experiment 2 had to make subjective judgments of co-occurrences for a total of 24 items, whereas participants in Experiment 1 did so only for 8 items. Having to make too many cue-target co-occurrence judgments may have hurt participants' performance on that task. Therefore, Experiment 3 attempted to increase the performance on co-occurrence judgments in two ways: 1) Decreasing the number of co-occurrence conditions (from 4 to 3), and 2) Increasing the participants' ability to discriminate differences in numbers of co-occurrences between one co-occurrence condition to the next.

EXPERIMENT 3

In Experiment 3, the cue-target co-occurrence levels were either one, three, or five, rather than one, two, three, or four, as had been the case in Experiments 1 and 2. The rationale for this manipulation was that the easier it was to discriminate among the co-occurrence levels, the more likely subjects would be able to base their TOT judgments on their judged frequency of cue-target co-occurrences. In addition, the presentation duration was further reduced to one second to keep recall levels low. It was predicted that most of Experiment 2 results would be replicated. TOT frequency and strength were predicted to linearly increase as a function of number of cue-target co-occurrences. A strong correlation between the judged number of co-occurrences and TOT strength was predicted. Also, the correlation between the actual and judged co-occurrences was predicted to be much greater than was found in Experiment 2.

Method

Participants

Forty eight undergraduate volunteers participated in Experiment 3.

Materials

The same materials (24 TOTimals) as those in Experiment 2 were used in Experiment 3. The twenty four items were divided in 3 groups of 8 items each. All eight cue-target pairs in a group were given the same number of co-occurrences for a given counterbalancing. The cue-target pairs co-occurred either one, three, or five times. The number of co-occurrences of items was

counterbalanced between subjects. The presentation duration is further reduced to one second.

Design and Procedure

A 3 X 3 (number of co-occurrences X counterbalancing) factorial design was employed. There were three levels of number of co-occurrences variable, either 1, 2, 3, or 3 co-occurrences, a within-subjects variable. And there were three different counterbalancings, a between-subjects variable. The design was almost the same as Experiment 2 except that there were three levels of co-occurrence conditions and the only difference in procedure was that each stimulus was presented for one second which was reduced from two seconds to keep recall rates from getting to high. For most of the analyses, one-way ANOVAs using the three levels of co-occurrence conditions as the independent variable were used. The same procedure as in Experiment 2 was used. In the study phase, participants studied 24 TOTimals. Right after the study participants performed recall or TOT judgments, subjective judgments on number of co-occurrences and then they were tested for their recognition memory in the identifying and matching tasks.

Results

Veridical TOTs

The effects of number of co-occurrences on TOT frequency and TOT strength were significant [$F(2, 94) = 12.81$, $MSE = 0.03$, $F(2, 94) = 11.62$, MSE

= 0.26, respectively]. Again, all ANOVA results using any TOT measures as the

dependent variable (e.g., proportion of TOTs out of all items or out of unrecalled

TABLE 6

Mean proportion of recall, partial recall and TOT frequency and TOT
strength by number of co-occurrences in Experiment 3

| | Number of Co-occurrences | | | | | |
| | One | | Three | | Five | |
	M	*SE*	*M*	*SE*	*M*	*SE*
Recall	0.01	0.00	0.16	0.02	0.22	0.03
Partial Recall	0.10	0.0	0.17	0.02	0.24	0.03
TOT frequency	0.13	0.02	0.23	0.02	0.30	0.03
TOT Strength	1.23	0.09	1.57	0.10	1.71	0.09

items) were consistently significant. Together with Experiments 1 and 2 results,

Experiment 3 result clearly demonstrated that increasing association strength

between the cue and target increased both TOT frequency and its strength (see

Table 6).

Spurious TOTS

TABLE 7

Average spurious TOT frequency and strength by number of actual and judged co-occurrences in Experiment 3

Co-occurrences	Number of Co-occurrences					
	One		Three		Five	
	M	*SE*	*M*	*SE*	*M*	*SE*
Actual Co-occurrences						
Frequency	0.53	0.03	0.53	0.07	0.54	0.04
Strength	1.69	0.08	1.88	0.08	1.84	0.10
Judged Co-occurrences						
Frequency	0.37	0.05	0.64	0.04	0.56	0.05
Strength	0.71	0.12	1.57	0.09	2.22	0.15

Table 7 displays the means and their standard errors for TOT frequency and strength data as a function of actual number of co-occurrences and also as a function of judged number of co-occurrences. An ANOVA examining the effect of actual number of co-occurrences on spurious TOT frequency did not reveal a significant effect, neither was that for spurious TOT strength significant. By contrast, the ANOVAs using the judged number of co-occurrences as the independent variable resulted in significant effects [for spurious TOT strength:

$F(2, 76) = 45.67$, $MSE = 0.49$; for spurious TOT frequency: $F(2, 76) = 11.88$, $MSE = 0.06$]. However, only the spurious TOT strength increased linearly as a function of judged number of co-occurrences. The effect of the number of judged co-occurrences on spurious TOTs was quadratic in nature. That is, TOT frequency was greater for the three co-occurrence condition than the other two conditions. Pair-wise comparisons revealed that only the 3 co-occurrence condition differed significantly from the one co-occurrence condition.

Pearson's correlation coefficients computed for between Judged number of co-occurrences and spurious TOT strength confirmed the positive significant relationship (r = 0.415). The correlation between actual number of co-occurrences and TOT strength was far from a significant level.

Recall

The proportion of correct recall increased significantly as a function of number of co-occurrences [$F(2, 94) = 34.70$, $MSE = 0.02$] even though overall recall level became substantially lower for the one co-occurrence condition compared to that condition in Experiment 2. Post hoc paired comparisons indicated that all means were significantly different from each other among the co-occurrence conditions.

Partial Recall

The percentage of items that were partially recalled for the three co-occurrence conditions were 10%, 17%, and 24% respectively. A significant effect of number of co-occurrences was revealed by an one-way ANOVA [$F(2,$

94) = 9.39, *MSE* = 0.02]; participants' partial knowledge about the target was more accurate as a function of number of co-occurrences. Post hoc pair-wise comparisons further revealed that the means were also different from each other.

Actual and Judged Co-occurrences

Experiment 3 was designed to increase the relationship between actual number of co-occurrences and judged number of co-occurrences by increasing the gaps in terms of number of co-occurrences among the conditions. This manipulation successfully improved the relationship between the actual and judged number of co-occurrences.
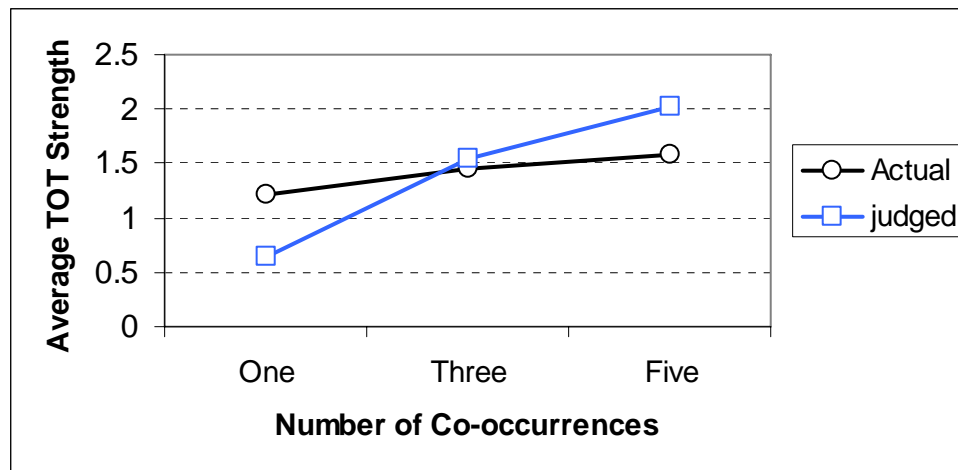

Figure 12. Average TOT strength as a function of actual and judged number of co-occurrences in Experiment 3

There was a significant effect of number of actual co-occurrences [*F*(2, 94) = 25.79 , *MSE* = 0.41]; the greater the number of actual co-occurrences, the greater the number of judged co-occurrences (see Figure 12). The effect size

(partial $\eta2$ = 0.35) was greatly improved compared to those obtained in

Experiment 1 (partial $\eta2$ = 0.28) and Experiment 2 (0.11). Pearson's correlation

coefficients were also computed between actual number of co-occurrences and

judged number of co-occurrences, between TOT strength and actual number of

co-occurrences, and also between TOT strength and judged number of co-

occurrences. All correlation coefficients were significantly greater than zero (rs =

0.16, 0.17, and 0.49 respectively). Once again, a stronger relationship was

found between the judged number of co-occurrences than between actual

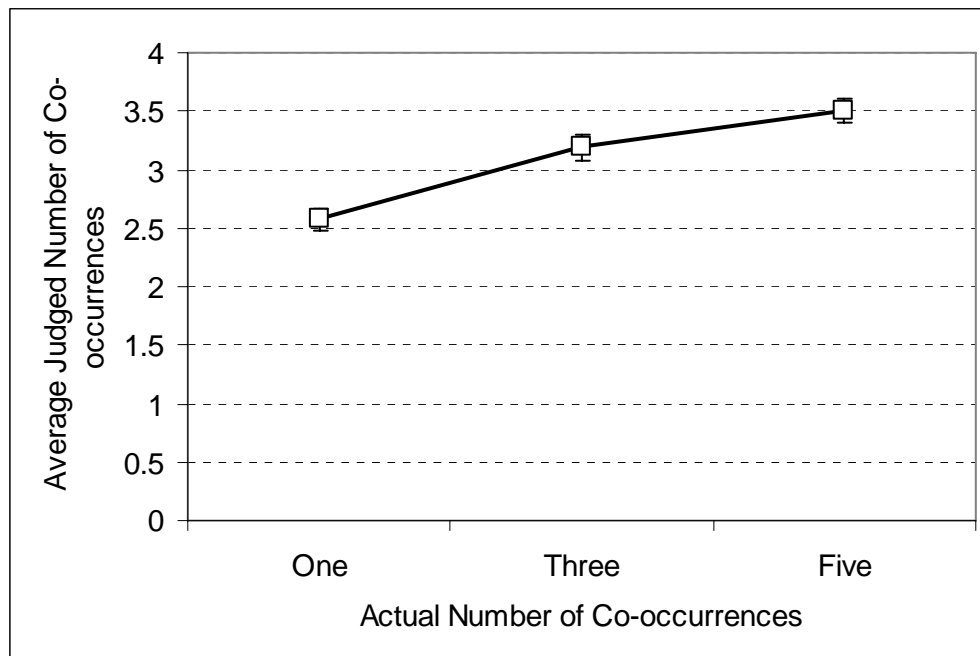number of co-occurrences and TOT and 0.488 respectively).

Figure 13. Average judged number of co-occurrences as a function of
actual number of co-occurrences in Experiment 3

Also, the two correlations were significantly different from each other ($t = -6.57$, p

< 0.001, two-tailed) as well. These relationships are visually represented in

Figure 13.

Identification and Matching
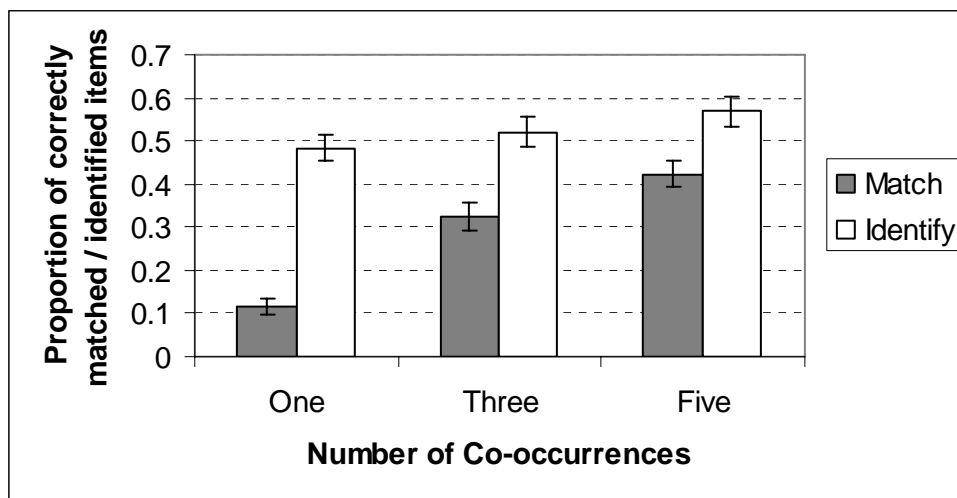
Figure 14: Proportion of correctly matched and identified items as a function of number of cue and target co-occurrences in Experiment 3

Mean percentage of correctly matched items among the unrecalled items

was 28.8% whereas mean percentage of identified was 52.4%. Two separate

ANOVAs were computed to examine the effect of number of co-occurrences on

people's abilities to correctly match and identify the studied items in the

recognition test. The greater the number of co-occurrences, the more cue-target

pairs were correctly matched [$F(2, 94) = 38.29$, $MSE = 0.03$] but the number of

correctly identified items did not vary as a function of co-occurrences [$F(2, 94) =$

2.80 , *MSE* = 0.03]. However, unlike the result of Experiment 2, there was a marginal increase across conditions (*p* = 0.07) (see Figure 14).

Discussion

Most of the results obtained in Experiment 2 were replicated in Experiment 3. Once again, increased connection strength between the cue and target concomitantly increased both TOTs and recall. Concerning spurious TOTs, there was no linear increase in TOT frequency or strength as a function of actual number of co-occurrences, but when the judged number of co-occurrences was used as the dependent variable, a significant correlation was found for spurious TOT strength.

Compared with Experiment 2, Experiment 3 was intended to improve participants' performance on the judgments of number of co-occurrences. Increasing the number of co-occurrences by two across conditions and reducing the number of conditions from four to three indeed improved the accuracy of their responses as expected. The correlations between TOT strength and number of co-occurrences were also greater than those obtained in Experiments 1 and 2. In addition, the relationship between the judged number of co-occurrences and TOT strength was found to be stronger than the relationship between the actual number of co-occurrences and TOT strength, as revealed by the correlation analyses.

GENERAL DISCUSSION AND CONCLUSION

One of the most important findings in this study was that an increase in association strength led to an increase in TOTs, consistent with the association strength heuristic. Support for the association strength heuristic was particularly strong when the recall level was kept low, allowing ample opportunities for TOTs. Recall levels were minimized in several ways, including the use of interference and delay (Experiment 1), increasing the number of critical items (Experiments 2 and 3), and reducing the presentation times (Experiments 2 and 3). If the target memory was not strong enough to be recalled, then increasing associative strength increased the frequency and strength of TOT states, even though recall levels did not increase.

In addition, across all three experiments, the number of judged cue-target co-occurrences was correlated with TOT strength to a greater degree than was the actual number of co-occurrences. The present study repeatedly demonstrated that increasing association strength increased TOTs even as correct retrieval of the target was also increased. This pattern of results is explained by the association strength heuristic.

Because only the association strength between the cue and target was varied in the present study, it is assumed that the cues were equally familiar to the subject and the target memorability was the same across all conditions. Participants saw the cue or the target equal numbers of times regardless of the condition; thus, the only difference across conditions was the number of cue-

target co-occurrences. Just like the familiarity heuristic in which familiarizing the cue leads to more frequent and stronger TOTs, or the accessibility heuristic in which providing more target related information leads to increases in TOT frequency, strengthening the association between the cue and target can also lead to more TOTs.

An alternative explanation may be inferred from the partial activation theory. According to the partial activation theory, a TOT is caused by incomplete activation that is insufficient for successful target retrieval. Strengthening the relationship between the cue and target may have increased target activation to a degree that was insufficient for the whole target to be retrieved but sufficient to induce TOTs under most conditions in the present study. The results of the present study are somewhat consistent with the partial activation theory in that the more often the subject saw the TOTimal's picture and name together, the more accurate were the subject's reports of partial information about the target.

A related theory called "the transmission deficit (TD) model" (Burke et al., 1991) provides important clues as to how and why TOTs might increase as a function of the number of cue-target co-occurrences. The TD model states that TOTs occur when the strength of the connections among phonological nodes is too weak to transmit sufficient priming for activation of the complete phonology of the TOT target word (James & Burke, 2000). In this model, priming is a form of sub-threshold excitation that prepares a node for activation or retrieval. The strength of connections to a memory target determines the rate and amount of

priming transmitted to them, which in turn determines whether or not a memory is retrieved from the long-term memory store. Recency and frequency of words, for example, strengthens connections, whereas aging weakens connections (Burke & MacKay, 1997; Burke et al., 1991; MacKay & Burke, 1990).

According to the TD model, the probability of a TOT is inversely related to the strength of the semantic-phonological connection for a word (Brown, 1991). Therefore, the inverse relationship between interference and TOTs (Experiment 1) may be explained by this theory. However, the TD theory does not provide a clear explanation for the result found in all three experiments of the present study, that increasing the strength of the connection from a semantic node (picture) to its corresponding phonological node (name) increased the probability of a TOT. The result of the present study may be complementary to the TD model because one can get partially activated traces not only by weakening strong memory traces with time or aging, but also with incomplete learning. It is possible that a certain level of target activation is required for a TOT and this activation level can be achieved either by weakening or strengthening of the target traces.

The magnitude of association one perceives between the cue and target appears to be an important factor in one's TOT reports. Any condition or manipulation that strengthens the cue-target association should increase TOTs. Strengthening the cue-target association too much, however, can facilitate target retrieval, resulting in a decrease in TOTs. This explains why a variable that often

increases TOTs can at other times lead to a decrease in TOTs. For example, Jones and Langford (1987) induced TOTs by presenting subjects with definitions of rare words. Right after the word definitions, the subjects were also shown phonologically or semantically similar words called "blockers" or "interlopers" to the target words. Subjects entered a TOT state more often when provided with a blocking word phonologically related to the target word than when they were provided with a word unrelated to the target. In Meyer and Bock's (1992) study, by contrast, a similar experiment using the same procedure found that phonologically related blockers led to increased target retrieval and reduced TOTs. One important difference between the two studies was that the Meyer and Bock (1992) study used easier target words, compared to the target words used in the former study by Jones and Langford (1987). This apparent difference may be explained by the association strength account of TOTs. The conflicting results between the two studies can be explained by the fact that a phonologically related word can either strengthen or weaken the association between the cue and target. Even when the relationship is strengthened by this manipulation, an increase or decrease of TOTs often depends on whether or not the target is easy enough to be retrieved. Regardless of whether the target was blocked or the target activation was not sufficient enough to be recalled, increasing association strength can lead to a TOT increase particularly under conditions in which the target has not reached to the recall threshold.

In the present study, the effect of strengthening associations on TOTs was more pronounced in the interference condition (Experiment1) and when the overall recall level was low-thus the target activation was reduced (Experiment 2 and 3). These results are consistent with both the blocking and the partial activation theories. Within each condition of Experiment 1, however, TOT increases did not depend on the magnitude of blocking or target activation because cue familiarity and target memorability were deliberately controlled in all experiments. Rather TOTs depended on the strength of the relationship between the cue and target.

These results are not only consistent with the data obtained in laboratory studies but they are also consistent with those obtained in naturalistic studies. Older adults experience TOTs more frequently, but remember parts or related information less frequently, in comparison with young adults (Burke et al., 1991; Cohen & Faulkner, 1986). These results are often explained by the transmission definition model which suggests that weakening of the connections between lexical and phonological representations due to aging leads to an increase in TOT states. An alternative explanation is possible using the association strength heuristic; that is, more frequent TOTs in older adults may occur because target specific memories are deteriorated by aging, whereas relational memories are relatively spared in older adults. Research has shown that item-specific memory is more vulnerable to forgetting than relational memory. For example, in Slamecka's (1966) study, which used nonsense syllable pairs, most of the errors

made in cued recall tests during the 0 – 18 hour interval were omission errors (instances of response unavailability), rather than associative errors (mismatch). When a person fails to produce a memory target, the person is most likely to enter a TOT state if s/he has the associative memory connecting the cue and the target. The stronger the association, the more frequent and stronger the TOT state.

Conclusion and Implications

In all three experiments, it was observed that participants used the association strength heuristic in judging their TOT states. In the present experiments, association strength was determined by manipulations of cue-target co-occurrences. The association strength heuristic can answer many of the questions posed by a body of TOT studies over the past two decades, such as why blockers or interlopers sometimes increase TOTs (Jones & Langford, 1987) and decrease TOTs at other times (Meyer & Bock, 1992); why older adults experience more frequent TOTs but remember less partial information of the target (Burke et al. , 1991; Cohen & Faulkner, 1986); why people have more TOTs for words that they have recently seen (Burke et al., 1989). In all of those cases, it is conceivable that with aging or a time lapse, the cue-target association strength may remain stable, even though the target memory, itself, may deteriorate. TOTs may be less influenced by the memorability of the target than by the perceived strength of the associations between cues and their targets.

The present study is innovative because, even though researchers have investigated the independent effects of cue and target memory on TOT judgments, no research has examined the effect of the cue-target association strength on TOT judgments. Considering the amount of research effort devoted to the effect of association strength on target recall, it is surprising that this one important aspect of memory has been neglected in the study of metamemory.

Not only does the present study provide a better understanding of TOT mechanisms and metamemory phenomena, in general, it provides a methodological paradigm that can be utilized to find an optimal combination of the levels of cue familiarity, target memorability, and association strength. Now that cue familiarity, target memorability, and association strength can be varied independently or in combination[1], one can investigate the individual or combined effects of the three components on any memory measures whether they are recall, recognition, or implicit memory. The paradigm developed in the present study, therefore, can be used not only for metacognitive research, but can be used in a broad range of research areas, such as memory, learning, and education.

---

[1] The number of target presentations can be varied, while keeping the number of cue, or cue-target co-occurrences constant, or both the number of cue and the number of cue-target co-occurrences can be varied, keeping the number of target presentations constant.

REFERENCES

Balch, W. R., & Shapiro, S. I. (1971). Studies of paired-associate learning as a

function of normative word-association strength. *Psychological Reports,*

*29,*187-190.

Bradley, M. M., & Glenberg, A, M. (1983). Strengthening associations: Duration,

attention, or relations? *Journal of Verbal Learning & Verbal Behavior, 22*,

650-666.

Brosgole, L., Hanley, M. J., & Contino, A. F. (1973). An analysis of repetition.

Psychological Reports, 32, 835-839.

Brown, A. S. (1991). A review of the tip-of-the-tongue experience. *Psychological*

Bulletin, 109, 204-233.

Brown, R., & McNeill, D. (1966). The "Tip of the Tongue" phenomenon. *Journal*

of Verbal Learning and Verbal Behavior, 5, 325-337.

Burke, D. M., MacKay, D. G., Worthley, J. S. & Wade, E. (1991). On the tip of

the tongue: What causes word finding failures in young and older adults?

Journal of Memory and Language, 30, 542-579.

Burke, D. M., Worthley, J.S., & Martin, J. (1988). I'll never forget what's-her-

name: Aging and tip of the tongue experiences in everyday life. In M.

M.Gruneberg, P. E. Morris, & R.N. Sykes (eds.), *Practical aspects of*

memory: Current research and issues (pp.113-118). New York: Wiley.

Choi, H., & Smith, S. M. (2005). Incubation and the resolution of tip-of-the-

tongue states. Manuscript submitted for publication.

Chuang, C. (1972). Effects of associative structure in verbal learning. *Acta Psychologica Taiwanica*, Mar, 67-91.

Cohen, G., & Faulkner, D. (1986). Memory for proper names: Age differences in retrieval. *British Journal of Developmental Psychology, 4*, 187-197.

Engelkamp, J., & Zimmer, H. D. (2002). Free recall and organization as a function of varying relational encoding in action memory. *Psychological Research, 66*, 91-98.

Engelkamp, J., Biegelmann, U., & McDaniel, M. A. (1998). Relational and item-specific information: Trade-off and redundancy. *Memory, 6*, 307-333.

Gallagher, J. W., & Reid, D. R. (1970). Effect of five free association strength values on paired-associate learning. *American Journal of Mental Deficiency*, *75*, 33-38.

Goss, A. E., & Nodine, C. F. (1965). *Paired-associates learning: The role of meaningfulness, familiarity, and familiarization*. Oxford, England: Academic Press.

James, L. E., & Burke, D. M. (2000). Phonological priming effects on word retrieval and tip-of-the-tongue experiences. *Journal of Experimental Psychology: Learning, Memory & Cognition, 26*, 1378-1391.

Jones, G. V. (1989). Back to Woodworth: Role of interlopers in the tip of the tongue phenomenon. *Memory & Cognition, 17*, 69-76.

Jones, G. V., & Langford, S. (1987). Phonological blocking in the tip of the tongue state. *Cognition, 26*, 115-122.

Kjeldergaard, P. M. (1968). Transfer and mediation in verbal learning. In T. R. Dixon & D. L. Horton (eds.), *Verbal behavior and general behavior theory* (pp. 67-96). Englewood Cliffs, N J: Prentice-Hall.

Koriat, A. (1993). How do we know that we know? The accessibility account of the feeling of knowing. *Psychological Review, 100*, 609-639.

Koriat, A., & Lieblich, I. (1974). What does a person in a "TOT" state know that a person in a "don't know" state doesn't know. *Memory & Cognition, 2*, 647-655.

Koriat, A. & Lieblich, I. (1977). A study of memory pointers. *Acta Psychologica, 41*, 151-164.

Metcalfe, J, Schwartz, B.L, & Joaquim, S.G. (1993). The cue-familiarity heuristic in metacognition. *Journal of Experimental Psychology,19*, 851-861.

Meyer, A. S., & Bock, K. (1992). The tip-of-the-tongue phenomenon: Blocking or partial activation? *Memory & Cognition, 20*, 715-726.

Read, J. D., & Bruce, D. (1982). Longitudinal tracking of difficult memory retrievals. *Cognitive Psychology, 14*, 280-300.

Reason, J., & Lucas, D. (1984). Using cognitive diaries to investigate naturally occurring memory blocks. In J.E. Harris & P.E. Morris (eds.), *Everyday memory: Actions and absentmindedness* (pp. 53-69). London: Academic Press.

Reder, L. M. (1987). Strategy selection in question answering. *Cognitive Psychology, 19,* 90-137.

Reder, L. M. (1988). Strategy control of retrieval strategies. In G. H. Bower (ed.),

   The psychology of learning and motivation, Vol. 22 (pp. 227-259). San

   Diego, CA: Academic Press.

Reder, L.M., & Schunn, C. D. (1996). Metacognition does not imply awareness:

   Strategy choice is governed by implicit learning and memory. In L. M.

   Reder (ed.), *Implicit memory and metacognition* (pp. 45-78). Mahwah, NJ:

   Erlbaum.

Schwartz, B. L. (1998). Illusory tip-of-the-tongue states. *Memory, 6*, 623-642.

Schwartz, B. L. (2001). The relation of tip-of-the-tongue states and retrieval time.

   Memory & Cognition, 29, 117-126.

Schwartz, B. L. (2002). *Tip-of-the-tongue states: Phenomenology, mechanism,*

   and lexical retrieval. Mahwah, N J: Lawrence Erlbaum.

Schwartz, B. L. & Metcalfe, J. (1992). Cue familiarity but not target retrievability

   enhances feeling-of-knowing judgments. *Journal of Experimental*

   Psychology: Learning, Memory, & Cognition,*18*, 1074-1083.

Schwartz, B. L. & Smith, S. M. (1997). The retrieval of related information

   influences Tip-of-the-tongue states. *Journal of Memory and Language, 36*,

   68-86.

Schwartz, B. L., Travis, D., Castro, A., & Smith, S. M. (2000). The

   phenomenology of real and illusory tip-of-the-tongue states. *Memory and*

   Cognition, 28, 18-27.

Slamecka, N. J. (1966). Supplementary report: A search for spontaneous recovery of verbal associations. *Journal of Verbal Learning and Verbal Behavior, 5,* 205-207.

Smith, S. M. (1994). Frustrated feelings of imminence: On the tip of the tongue. In J. Metcalfe & A. Shimamura (eds.), *Metacognition: Knowing about knowing* (pp. 27-45). Cambridge, MA: MIT Press.

Smith, S. M., & Blankenship, S (1991). Incubation and the persistence of fixation in problem solving. *American Journal of Psychology, 104.* 61-87.

Smith, S. M., Balfour, S. P., & Brown, J. M. (1994). Effects of practice on TOT states. *Memory, 2,* 47-53.

Smith, S. M., Brown, J. M., & Balfour, S. P. (1991). TOTimals: A controlled experimental method for observing tip of the tongue states. *Bulletin of the Psychonomic Society, 29*, 445-447.

Spence, D. P., & Owens, K. C. (1990). Lexical co-occurrence and association strength. *Journal of Sycholinguistic Research, 19*, 317-330.

Widner, R. L. Jr., Smith, S. M., & Graziano, W. (1996). Effects of demand characteristics on feeling of knowing and tip of the tongue reports. *American Journal of Psychology, 109*, 525-538.

APPENDIX 1

TOTimals USED IN THE STUDY

Atiphus   Cronipin   Gallid   Harliwit

Ormon   Pirlin   Scavil   Urrasin

Filler items used in Experiment 1

Binn   Ibil   Drosselpen   Ermalope

Flim   Kolf   Laice   Merlinger

Narp   Quike   Rachorel   Turnk

Vithon   Wombok   Yelkey   Zelamus

Note. All TOTimals were critical items in Experiments 2 & 3

APPENDIX 2

RESPONSE FORM USED IN EXPERIMENT 1

Recall Test

Please answer the following questions for each item.

A. What is this animal's name?

B. Are you in a TOT state ?

    0 (not at all)   1 (weak)   2 (medium)   3 (strong)
    |_____|_____|_____|

C. Do you remember any parts of the name (e.g., first or last letter, any syllable, rhymes, etc)?

D. How many times, you think, you saw the picture and the name together?

    1. once   2. twice   3. three times   4. four times

1. A._____ B._____ C._____ D._____

2. A._____ B._____ C._____ D._____

3. A._____ B._____ C._____ D._____

4. A._____ B._____ C._____ D._____

5. A._____ B._____ C._____ D._____

6. A._____ B._____ C._____ D._____

7. A._____ B._____ C._____ D._____

8. A._____ B._____ C._____ D._____

Recognition Test

1_____ 2_____ 3_____ 4_____

5_____ 6_____ 7_____ 8_____

APPENDIX 3

MATCHING TEST FORM

Student ID_____

Circle the correct names of the animals that you saw in the presentation

Halliwit		Quicke		Wombok		Attipus		Yelkye		Rachoral	
Bine		Gallad		Tulnk		Harliwit		Film		Korfe	
Viethorn		Vonthin		Zelapus		Railce		Ibbil		Harssin	
Yelko		Marlinger		Gallin		Cronopin		Urrassin		Ormon	
Laise		Binn		Ermabil		Vithon		Narp		Ermolope	
Crophus		Drozzlepen		Rockoreal		Cavis		Turnk		Layce	
Orsil		Pilin		Tunkr		Haliwit		Perlin		Drosselpen	
Drosleper		Ormen		Binh		Gallid		Rapael		Oman	
Cornipin		Ermalope		Blim		Merliwit		Qiuke		Pirlin	
Urrosin		Gallit		Qicklin		Zepefe		Koft		Trnsk	
Flim		Quick		Merline		Vionth		Cavil		Wormbok	
Finlm		Antiphus		Laice		Droslepen		Narnk		Cronipin	
Pirline		Atipus		Yelkay		Yelkey		Farp		Quike	
Harliwet		Wanbok		Narpe		Leice		Merlinger		MalinKer	
Rokorel		Wombil		Lachol		Wombork		Urrarel		Cronophin	
Binne		Cornopin		Urassin		Filim		Turnvil		Scavis	
Atiphus		Harliwitt		Urasin		Korlf		Yolkey		Kolff	
Wombock		Zelamus		Ibil		Orman		Kalf		Viton	
Atimus		Vithorn		Narlp		Laiss		Omon		Ermelope	
Imbl		Ibel		Scacke		Zellamus		Kolf		Rakoral	
Imbel		Pirline		Antiphus		Biln		Scovil		Urrasin	
Firlim		Drossilepen		Galid		Yellkey		Emolope		Emalope	
Narpin		Merlinge		Turnke		Pirlid		Zalemus		Scavil	
Scavel		Rachorel		Naper		Quikel		Zelamuse		Drosslim	

APPENDIX 4

IDENTIFICATION TEST FORM
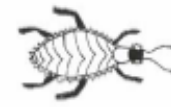
VITA

Hyun Choi

Contact Information

Psychology Department,
Texas A&M University
College Station, TX 77843
Phone: 979-997-2125
Email: choi1h@hotmail.com

Education

Ph.D. in Psychology, Texas A&M University, College Station, Texas, May, 2005
M.S. in Psychology, Central Michigan University, Mt. Pleasant, Michigan, 2000
B.S. in Psychology, Southwest Minnesota State University, Marshall, Minnesota, 1997
B.A. in Law, Hankuk University of Foreign Studies, Seoul, Korea, 1992

Research Experience

Graduate Research Assistant
Department of Psychology (Cognitive Division)
Texas A&M University, College Station, TX, 2000, September -2005, May

Teaching Assistant

Cognitive Psychology (undergraduate)
Research Methods

Publications

Smith, S. M., Gerkens, D.R., Pierce, B. H., & **Choi, H**. (2002). The roles of associative responses at study and semantically guided recollection at test in false memory: The Kirkpatrick and Deese hypotheses. *Journal of Memory and Language, 47*, 436-447.

Choi, H., & Smith, S. M. (in press). Incubation and the Resolution of Tip-Of-the-Tongue States. *Journal of General Psychology*.