1991

The Effects Of Self-referencing In The Processing Of Linear Ordering Relations

Hsiao H. d'Ailly

ISBN 0-315-71990-7

Abstract

The purpose of the present research was to investigate the effects of self referencing in the processing of linear ordering relations in a task designed to simulate certain aspects of classroom mathematics instruction. In each of three experiments, undergraduate students enrolled in an introductory psychology course were asked to read a series of paragraphs each of which contained a 5-term linear ordering relation (e.g., A > B > C > D > E). After this information was encoded, subjects were asked to make pair-wise comparisons of these 5 terms. Two major factors were tested: the inclusion of a "You" term (Self-Referencing) among the 5 terms, and the position of the "You" term (Position of Self-Referencing) in the ordering. In Experiment 1, the "You" term was placed at three positions: first, third and fifth. Experiment 2 extended the investigation to all five positions. Experiment 3 was designed to replicate the findings from the previous two experiments and to increase the power of statistical tests of the Self-Referencing effect. The results of all three experiments were consistent. Self-Referencing did not result in a difference in overall performance. However, the Position effect and the interaction of Self-Referencing with other variables demonstrated that self-referencing had a strong impact on cognitive processing. When the "You" term was included, subjects appeared to use it as a focus in organizing information, and the further away this self-focus point was from the endpoints, the worse performance became. When test questions were related to the self, reaction times were shorter, whereas when questions did not involve a self term, reaction times were slower. The endpoint effect and the distance effect reported in previous research were also tested. It was found that when the "You" term was included in various positions in the linear ordering, the endpoint effect changed accordingly. The distance effect was not evident in the present research. Implications for educational and cognitive research were discussed.

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The purpose of this research was to investigate the cognitive effects of self referencing in an educational context. For this thesis, "self-referencing" is defined as any form of incorporation of personal reference into an educational task for the purpose of improving students' cognitive performance. Personal reference might involve direct reference to the student by name, or by the word "You". Alternatively, self-referencing might consist of introducing materials or facts of personal relevance to the student. For example, some computer assisted instruction programs refer to students by their own names or by the term "You" in order to encourage self referencing and to encourage the learner's personal involvement in the task.

There is evidence, both from common experience and from research in psychology, that people react differently to situations that involve personal reference. One case in point is the well known "cocktail party phenomenon" (Cherry, 1953), in which a person attending to one conversation is able to detect mention of their own name in a separate conversation taking place some distance away in a noisy room. As with other research on factors affecting human learning and memory, the question arises as to whether the self-referencing effect can be applied to the improvement of student performance in real-world educational contexts. The field of educational psychology, within which this thesis is formulated, seeks to identify principles of learning and memory with strong empirical support that can be implemented in classrooms to improve student academic performance. Thus the question of interest is whether self-referencing will produce higher levels of attentiveness, motivation, and performance in students, and thus result in more effective learning of academic tasks. The academic task of main concern in the present research is that of mathematics education.

A considerable body of research in educational psychology over the past 20 years has been devoted to the teaching of mathematics in schools (e.g., Lester & Garofalo, 1982; Romberg & Carpenter, 1986). Evidence available to date indicates that self-referencing may indeed be one of the factors that teachers and other educators can use to improve the learning of mathematics (e.g., Arnand & Ross, 1987; Davis-Dorsey, Ross & Morrison, 1991; Wright & Wright, 1985). For example, as detailed below, Wright and Wright (1985) found that incorporating personal information (e.g., student's name, name of the student's favourite household pet) into mathematics problems led to improvement of student performance. The nature of this facilitative effect, however, is not well understood. As pointed out by many researchers, mathematics educators need to draw upon the work being done by psychologists, and there is also a need for psychologists to establish basic principles of learning, memory, and cognition that are relevant to tasks in mathematics education (Lester & Garofalo, 1982). Indeed, the bridging between educational and cognitive research has a great potential in bettering both fields. Studies in cognitive psychology can serve as an superb ground for educational researchers. On the other hand, observations in educational research also provide excellent resources for further cognitive investigation.

This thesis investigates the effects of self-referencing in a laboratory task that relates closely to mathematics problem solving that occurs in the classroom, namely the linear ordering task. In a linear ordering task, subjects are asked to encode a linear ordering relation among several terms (e.g., Tom is taller than John, John is taller than Paul, and Paul is taller than Rod). Then questions involving pair-wise comparison of the terms are presented to subjects (e.g., John is taller than Rod?). Comparative processes of this sort are commonplace and important in solving mathematics problems. Students in mathematics classrooms are constantly required to compare and order two or more terms on various dimensions. Furthermore, recent research suggests that students find mathematics problems more difficult when, as is the case with linear ordering tasks, they contain relational statements (Loftus & Suppes, 1972, Mayer, 1982; Greeno, 1980; Riley, Greeno & Heller, 1982). Students were said to have more difficulty in representing relational statements.

For example, in Mayer's (1982) study on algebra story problems, subjects made approximately three times as many errors in recalling relational statements (e.g., the picture is 4 inches longer than it is wide) as in recalling assignment statements (e.g., the frame is 2 inches wide). Thus, it is believed that testing self-referencing effects on a laboratory task that relates closely to mathematics problem solving will contribute significantly to our understanding of the role of self-referencing in mathematics learning in real-world classrooms.

Prior research on the effect of self-referencing has been conducted both in laboratory settings and in actual classrooms using realistic curricular materials. These two areas of research are reviewed in turn below.

Laboratory Studies of the Self-Referencing Effect

The effects of self-referencing have been empirically investigated several times in laboratory settings. Research shows, as detailed below, that memory for information can be enhanced by encoding the information with reference to self (e.g., Bellezza, 1984; Bower & Gilligan, 1979; Brown, Keenan, & Potts, 1986; Ganellen & Carver, 1985; Keenan & Baillet, 1980; Kuiper & Rogers, 1979; Rogers, Kuiper, & Kirker, 1977).

The Depth-of-Processing theory (Craik & Lockhart, 1972) states that the retention of a memory trace is determined by the nature of encoding operations carried out on stimulus material. For example, reading a word can be seen as composed of a sequence of operations in which the visual properties of the stimulus are processed, then a name or label is formed for this configuration, and finally, the meaning of the word placed in a context of our knowledge about this and related events. Craik and Lockhart (1972) saw this sequence as a continuum in which deeper processing produced progressively more meaningful information. Research has shown that meaningful analysis (semantic coding) forms a more durable trace than does shallow, structural analysis of the sound or appearance of stimuli.

Until 1977, semantic encoding was commonly considered the optimal way of achieving good retention (Klein & Kihlstrom, 1986). However, in an extension of the depth of processing theory, Rogers, Kuiper and Kirker (1977) demonstrated that judging stimulus materials in terms of personal descriptiveness (self-referent encoding) produced an even higher level of recall than semantic encoding. In the Rogers, Kuiper, and Kirker (1977) study, forty adjectives were presented to subjects each followed by a cue, which would lead subjects to process the word differently (e.g., "Big letters?", "rhymes with xxxx?", "Means same as YYYY?", or "Describes you?"). After being presented with all the words, subjects were asked to free recall the words that they encountered. It was found that the self-referencing task produced the best recall. These findings have been replicated and supported by several other studies (e.g., Keenan & Baillet, 1980; Kuiper & Rogers, 1979).

As described by Rogers et al. (1977), the involvement of self in the interpretation of new stimuli imparts a degree of richness and fullness to the input because of the availability of immense amounts of previous experience embodied in the self. The self-referencing effect found in several studies has led some researchers to believe that "self" is a highly elaborate memory structure or schema (e.g., Ingram, Smith, & Brehm, 1983; Keenan & Baillet, 1980; Markus & Smith, 1981). When self schema are activated, many links are formed between the stimulus and preexisting information about the self in memory. Thus, involving "self" in a piece of information has the effect of encouraging a deeper level of processing, which may produce more meaningful information and therefore result in better memory of the information.

Self-Referencing Effect in Mathematics Education

Self-referencing has also been shown in several studies as a facilitative factor in classroom mathematics education. Wright and Wright (1985) reported that personalized mathematics word problems were easier for students to solve than non-personalized problems. In their study, children's personal information, such as their names, and their favourite pets, was obtained from an interest inventory.

This information was then entered to a computer program and personalized word problems, such as following, were generated according to these personal variables. For example, if a student's name was "John" and his favourite pet was a "dog", the mathematics question would be presented as the following:

> John's dog got into the chickens.
> and ate 1/3 of the 18 chickens,
> How many chickens did the dog eat?

The results showed that this treatment did manifest a significant improvement in student performance relative to problems presented in a standard format. Also, students were better in selecting the arithmetic process necessary for problem solution on personalized test items.

Other research indicates that students learn better and are more interested if they are given personalized examples during mathematics instruction. Arnand and Ross (1987) found that providing personalized examples facilitated the learning of problem-solving procedures. In their study, fifth and sixth grade children were given one of three versions of a computer-assisted lesson on the division of fractions. In one version, examples were personalized by incorporating student's personal information into the problem context. For instance, the following is an example of the personalized-context version presented to a student. The underlined terms were personal information provided by the student:

> Joseph's teacher, Mrs. Williams, surprised him on December 15 when she presented Joseph with 3 Hershey Bars. Joseph cut each one of them in one-half so that he could share the birthday gift with his friends. In all, how many pieces of Hershey Bars did Joseph have for his friends?

In the other two versions, concrete contexts and abstract contexts were used. The following examples were given in the Arnand and Ross study for the concrete and abstract versions respectively:

> Billy had 3 candy bars. He cut each one of them in half. In all, How many pieces of candy bar did Billy have?

> There are 3 objects. Each is cut in one-half. In all, How many pieces would there be?

The results showed that the personalized-context group performed better than the other two groups in solving both standard and transfer problems, and in recognizing rule procedures. In addition, students in the personalized-context group showed more positive attitudes toward the task than those in the other two groups.

The research evidence suggests, therefore, that self-referencing can have a positive impact on mathematics learning. Indeed, the typical strategy recommended in mathematics teaching is to personalize the problems, or to make the problems relevant to students themselves.

A few explanations have been suggested for this facilitative effect. One explanation is that when problem context is personalized, students are more motivated and therefore more attentive to the problem (Davis-Dorsey, Ross

& Morrison, 1991). In addition, personalized problems have the advantage of cognitively being more meaningful to students. As Davis-Dorsey, Ross, and Morrison (1991) described, personalized problems enable students to form connections between the problem information and existing schema, which in consequence helps students create appropriate problem representations. These explanations relate the self-referencing effects either to a motivational factor or the accessibility and activation of information in long-term memory.

Though the effect of self-referencing on memory has been investigated in the laboratory, the tasks used in laboratory experiments described earlier do not necessarily relate well to a mathematics learning context. The present study was done under laboratory conditions, but investigated the effect of self-referencing using an mathematically-relevant task, namely a linear ordering task. Subjects were asked to encode a linear ordering relation among several terms (e.g., You are taller than Tom, Tom is taller than John, John is taller than Paul, Paul is taller than Rod). Then several pair-wise comparison questions were presented to the subjects (e.g., John is taller than Rod?). This task is chosen because cognitive processing of linear ordering relations is common and important in mathematics. In a mathematics task, students are constantly required to process information about relations between two or more variables, and quite often a decision has to be reached in terms of which variable is greater or smaller. Therefore, an examination of the self-referencing effect on a linear ordering task would seem to be a good starting point in understanding whether self-referencing facilitates learning in mathematics in classrooms, and if so, why and how it facilitates learning.

General Findings on Linear Ordering Tasks

Subjects performing a linear ordering task typically are presented with information on pair-wise relations among terms (e.g., A>B, B>C, and C>D). The following paragraph is one example:

> "In a small forest just south of nowhere, a deer, a bear, a wolf, and a hawk were battling for dominion over land. It boiled down to a battle of wits, so intelligence was the crucial factor. The bear was smarter than the hawk, the hawk was smarter than the wolf, and the wolf was smarter than the deer..........."
>
> (Potts, 1972, p.730)

Subjects are given plenty of time to encode, organize and memorize the information. After they become familiar with the materials, subjects are asked to make a judgement on whether various statements presented are true or false based on the information presented to them (e.g., "The wolf was smarter than the hawk."). Their reaction times and error rates on these questions are measured. This paradigm allows researchers to study how people compare two terms in a linear ordering relation.

There has been considerable research aimed at determining how humans store simple linear ordering information (e.g., A>B>C>D), and how they process this information to solve problems such as "Is A>D?". These studies, however, have differed widely in the kind of information they chose. Some used object names with preexisting or perceptual ordering, such as digit numbers, or animal sizes (e.g., Banks, 1976; Moyer, 1973). Others applied artificial linear ordering relations by arbitrarily assigning relations between terms (e.g., Mayer, 1978; Moyer & Bayer, 1976; Potts, 1972, 1974; Scholz & Potts, 1974; Sternberg, 1980a; Sternberg, 1980b; Sternberg & Weil, 1980). There are also some studies where these two methods were combined. In the latter studies, people are trained to associate certain terms (e.g., color names) with perceptual linear ordering objects (e.g., sticks with different lengths) and then tested on the trained linear ordering relations between these terms (e.g., Trabasso, Riley, & Wilson, 1975; Moyer & Bayer, 1976).

In a linear ordering task, the test pairs can be classified as either adjacent pairs (e.g., A-B, B-C, C-D), or remote pairs (e.g., A-C, A-D, B-D). Moreover, for each linear ordering there are always two end terms (e.g., A and F in a 6-term A-B-C-D-E-F linear ordering). Research evidence indicates that people are more accurate and faster at answering questions about remote pairs than they are about adjacent pairs. Thus, the further apart the two terms are, the better the performance. This phenomenon is referred to as the distance effect. Moreover, superior performance has consistently been found on pairs containing the end terms. This is referred to as the endpoint effect.

Distance and endpoint effects have been reported in many different studies. These effects appear to be evident for both young children and adult populations. For example, Trabasso and Riley (1975) tested a linear ordering task on three age groups, namely 6-year olds, 9-year olds, and adults. The results of their studies indicated the distance and endpoint effects were apparent across all three age groups. Therefore, the cognitive processing young children carry out on a linear ordering task appears to be similar to that of the adults. This finding gives some credence to the view that the results of the present study can be generalized from college students working on laboratory tasks to young children in mathematics classes.

As the present study uses tasks similar to the ones used by Potts (1972), studies done by Potts are reviewed in greater detail.

Studies of Artificial Linear Ordering Tasks

Potts (1972) investigated the strategies subjects employed in trying to learn meaningful verbal material consisting of linear ordering relations. Subjects were asked to learn a paragraph containing linear ordering relations of four terms (e.g., A>B>C>D) and then were tested on their knowledge of the ordering (e.g., is A>B?). Although all tasks in his study contained a four-term linear ordering, they differed in the amount of information presented. The following is a sample paragraph in his study.

> "In a small forest just south of nowhere, a deer, a bear, a wolf, and a hawk were battling for dominion over land. It boiled down to a battle of wits, so intelligence was the crucial factor. The bear was smarter than the hawk, the hawk was smarter than the wolf, and the wolf was smarter than the deer. On a small pond in middle of the same forest, another contest for dominion was being waged. The contenders were a frog, a clam, a duck, and a fish. In this case, however, the battle was to be decided by an election, and friendliness was the crucial factor. The fish was friendlier than the frog, the frog was friendlier than the clam, and the clam was friendlier than the duck. In addition, the fish is friendlier than the clam, the frog was friendlier than the duck, and the fish was friendlier than the duck. In the end, each of the battles was decided in its own way. The tranquillity returned to the area."
>
> (Potts, 1972, p.730)

As shown in this example, there were two linear orderings incorporated in this paragraph where pairwise relations were described. The first part of the message contained only adjacent pairs, while the second part of the message described both adjacent and remote pairs. The results showed that regardless of whether remote pairs were actually presented or not, responses to remote pairs were faster and more accurate than responses to adjacent pairs (distance effect). Thus, Potts (1972) concluded that subjects not only stored the information presented, but also stored inference information in memory. Another interesting finding was that, although the distance effect was evident, response times were not a simple decreasing function of remoteness. For example, reaction times for the two questions, B>C? and C>B?, where no end terms were involved, were relatively longer than others.

Potts (1974) replicated this study and extended the research to a six-term linear ordering task. In the first experiment, he replicated his earlier study using a much larger sample of paragraphs. A set of 20 paragraphs was constructed, each describing a four-term linear ordering. All the paragraphs in this experiment contained information about adjacent pairs only.

Subjects were given as much time as they needed to study the paragraph and were tested with 12 test sentences (6 true and 6 false) for each paragraph. The results of this experiment again showed that reaction time to the remote pairs was consistently shorter than reaction time to the adjacent pairs. A simple distance effect, however, could not account for all of the data. For example, there was a strong interaction between type of pair and truth value of the test sentence. Reaction times to true sentences beginning with A (A>B?) were shorter than reaction times to the corresponding false sentences ending with A (B>A?). Reaction times to true sentences ending with D (e.g., B>D?), on the other hand, were longer than reaction times to false sentences beginning with D (e.g., D>B?)

In the second experiment, Potts (1974) gave subjects three paragraphs to study simultaneously. By doing this, he reasoned that subjects would be forced to store and retrieve information in long-term memory (LTM) instead of retaining all the information in short-term memory (STM) as they might have for the first experiment. The results of this experiment were very similar to those obtained in the first experiment.

In the third experiment, Potts (1974) increased the number of terms in the ordering relation to six. By examining the reaction time profile on the four inner terms of a six-term ordering (BCDE), it was possible to investigate the distance effect without confounding with the endpoint effect. Twelve paragraphs, each describing a single six-term linear ordering were constructed. The ordering was established by presenting the five adjacent pairs in the chained order: A>B, B>C, C>D, D>E, E>F.

Data from this experiment again demonstrated the superiority of performance on remote pairs. Moreover, the distance effect was revealed even when the endpoint effect was eliminated. For the inner pairs (BCDE), reaction time to remote pairs was also significantly shorter than reaction time to adjacent pairs. Furthermore, a significant endpoint effect was observed. Reaction times were shortest to the five test sentences beginning with the first term (A) in the ordering and relatively short to the five sentences beginning with the last term (F).

In conclusion, Potts' studies showed strong evidence for distance and endpoint effects in linear ordering tasks. Subjects were faster on remote pairs than on adjacent pairs. This was true regardless of whether the remote pairs were presented in the reading paragraph or not. Moreover, even with endpoint effects controlled, distance effects could be observed with the inner pairs.

Models for Explaining Distance and/or Endpoint Effects

Several models have been proposed to explain the distance and endpoint effects found in linear ordering tasks. These provide a basis for understanding the cognitive processing that occurs in a linear ordering task, and perhaps for understanding the impact of self-referencing on cognitive processing. Models proposed to date include the rating-scale or spatial imagery model (Potts, 1972), the end-term anchoring model (Potts, 1972), the two dimensional model (Scholz & Potts, 1974), the feature-frequency model (Humphreys, 1975), the spatial strategy model (Trabasso and Riley, 1975), the associative strength model (Trabasso and Riley, 1975) and the scan plus comparison model (Moyer and Bayer, 1976).

Despite the great methodological differences among these studies, all the models except the feature-frequency model adopt the assumption that people form a linear ordering scale to organize information. Moreover, the construction of the linear ordering representation, as described by Trabasso and Riley (1975), is "ends-inward". Subjects are said to isolate the end-anchor terms, and then place them on the two ends of the scale first. For example, in a 5-term linear ordering relation, the end pairs, (A,B) and (D,E), would be first placed, then the (B,C) and (C,D) pairs. Since the serial lists are learned from the end points inward, according to Potts (1972), the first and last terms in the list share a special status in serving as anchors for the other terms in the list. This end-term anchoring theory provides an explanation of why the test pairs involving endterms were found to be easier.

Moreover, since subjects used a linear ordering scale to organize information, they accessed the underlying scale or a linear array in order to derive an answer. The literature has demonstrated that the distance between terms in a linear ordering scale is inversely proportional to speed. For example, when college students were asked to decide which of two letters occurred later in the alphabet, the reaction time was inversely related to the ordinal distance between the displayed letters (Parkman, 1971). Similarly, the reaction time for comparing the magnitudes of single digits was found to relate to their separation in the number series (Aiken & Williams, 1968; Moyer & Landauer, 1967; Parkman, 1971; Sekuler, Rubin & Armstrong, 1971). The basic notion for the rating scale theory is quite simple.

As Potts (1978) pointed out, the further apart the two terms, the more discriminable the difference between them and the easier the comparison.

The theory assumes that, when confronted with a linear ordering task like that used in the Potts study, people form a linear ordering scale to organize the information. Therefore, the distance effect can be expected. As Scholz and Potts (1974) concluded, a two-dimensional model with a combination of the end-term anchoring theory and the rating-scale theory can best describe the data observed from their studies.

The Present Research

The present research tested the self-referencing effect using 5-term (A>B>C>D>E) linear ordering tasks similar to those used by Potts. Because these tasks appeared to be more appropriate to adult populations, the present studies used university students as subjects. As mentioned earlier, research evidence has shown that both the endpoint and distance effects observed in linear ordering tasks are common to adults and young children. It appears that young children process linear ordering relations in a similar fashion as adults. Therefore, it is expected that observations from the present studies have a reasonable chance of generalizing to younger populations.

In the experiments reported below, subjects were presented with a paragraph containing a 5-term linear ordering relation such as the following:

> Students are voting for their leader. Tom gets more votes than John, John gets more votes than You, You get more votes Rod, and Rod gets more votes than Paul.

After reading the paragraph, subjects were asked to make a judgement on whether a statement on pair-wise comparison is true or false (e.g.,"Rod got more votes than Tom").

The main dependent variable measured in the present research was subjects' reaction time (RT) to the questions. Since the linear ordering task is relatively easy, subjects were expected to be able to answer the questions with a high accuracy rate. The focus of interest, therefore, lies on how fast subjects can respond to the questions. From an information processing point of view, even when all subjects show close to 100% accuracy on a task, the faster RT means that more short term memory (STM) capacity is free for other tasks. Since STM is known to have limited capacity, being able to process information faster indicates that the amount or the complexity of information that can be processed at the same time is increased. Thus, tasks that require shorter RT are considered as beneficial in performance and facilitative in learning.

The theory underlying the present research is that including a "You" term in the ordering would not only motivate people more, but also change the way people store and process information. When there is a "You" term involved in the ordering relations, people will not only be more motivated to do the task, but will also be more attentive to the "You" term and possibly tend to use it as a focus (self-focusing strategy) to organize information.

The major factors investigated in this research were the inclusion of a "You" term in a linear ordering task (Self-Referencing), and the position of the "You" term in the ordering (Position of Self-Referencing). Because this research was viewed as basically exploratory in nature, no formal predictions or hypotheses were stated. However, it was generally expected that by including a self referencing term, "You", in the linear ordering relation, subjects would be more motivated to perform the task, and, therefore, the overall performance would be improved. Moreover, since subjects would possibly utilize a self-focusing strategy in organizing information, it was expected that the mental representation of the linear ordering relation might possibly be altered when the "You" term was placed at different positions in the linear ordering task.

It is not clear, however, how the position of the "You" term should affect overall performance. One possibility is that when the "You" term is placed at positions other than the two ends, it provides subjects with an extra focus. Therefore, it facilitates overall performance. On the other hand, it is also possible that by placing the "You" term at positions other than the two ends, somehow the positive effect of these two end anchors will be eliminated or compromised, thus inhibiting overall performance.

Since it is not clear if positioning a "You" term in a linear ordering task will affect the dynamic relations among other terms, it is worthwhile to look beyond overall performance, and conduct further analyses among different pairs within a task. In a 5-term linear ordering, 20 pair comparisons can be generated. One way to look at these 20 pairs is whether they include a "You" term or not. That is, whether or not the test pair itself is self-referencing (Self-Reference Pairs vs. Other Pairs) constitutes an important variable of interest (Pair Type). If subjects are simply more motivated to do the task when there is a "You" term involved, then including the "You" term might be expected to produce shorter RTs for both Self-Reference pairs and for Other Pairs. On the other hand, if involving a "You" term affects performance in other ways - for example, in terms of self-focusing memory strategies, then it is possible that the results might show a statistical interaction between Self-Referencing and Pair Type. For example, Self-Referencing might result in a stronger facilitative effect on Self-Reference Pairs than on Other Pairs.

Another goal of this study was to examine the endpoint and distance effects that were found in previous research on linear ordering tasks, and to test the impact of inserting a "You" term on these effects. The endpoint effect was examined with a control of distance. Only the adjacent pairs (A-B, B-C, C-D, D-E) were used in the test. These pairs can be mapped to four serial positions. If there is an endpoint effect, a serial position curve would be expected, with the two ends having the shortest reaction times.

Expectations regarding serial position effects were different for the two conditions where the "You" term was either involved or not involved in the task. Based on the end-term anchoring theory, it was expected that when no "You" term was included in the task, a serial position effect would be observed on the adjacent pairs. On the other hand, when a "You" term was included in the linear ordering, it was expected that subjects might use a self-focusing strategy in processing and organizing information. Therefore, depending on the position of the "You" term, the serial position curve might change accordingly. In particular, when the "You" term was positioned in the middle, it may result in a decrease in the strength of the endpoint effect.

The distance effect was also tested with control of the two end anchors. Thus, only the inner terms (BCD) were included in the testing. For the distance effect, it was expected that the 2-step pairs (B>D, D>B) would have shorter reaction times than the 1-step pairs (B>C, C>B, C>D, D>C). This expectation is based on the assumption that subjects form a linear ordering scale to organize information. It should be noted, however, that if people use the "You" term as a focus to organize information, the control for anchors or special focuses would not be successful when there is a "You" term involved in the task.

In short, the purpose of the present research was to investigate the effect of self-referencing in a linear ordering task. The first question was whether self-referencing in a 5-term linear ordering task would result in an overall superior performance. By examining the effect on different types of pair comparisons (Pair Type), namely Self-Reference vs. Other pairs, the present study also tested whether Self-Referencing effects are general or specific to certain types of test questions. The third goal was to determine whether placing the self term at different positions on a linear ordering would have different impact on performance. Finally, the impact of these manipulations on the endpoint effect and the distance effect was also examined.

Experiment 1

The purpose of the first experiment was to obtain preliminary, exploratory data regarding the self-referencing effect in a linear ordering task. Two manipulations were applied: the inclusion of self as a term in the linear ordering task (e.g., Tom>John>You>Rod>Paul, vs. Tom>John>Bob>Rod>Paul), and the position of the self term in the linear ordering relation. A split-plot design was used with the inclusion of the self term (Self-Referencing) as a between-subjects manipulation and the position of the self term (Position of Self-Referencing) as a within-subjects manipulation. Therefore, the experimental group had the "You" term included in their task (Self-Referencing group), whereas the control group did not. For each subject, the "You" term (or a control term) was placed at three different positions: Position 1 (A), Position 3 (C), or Position 5 (E). The main dependent variable was reaction time (RT) for the test pairs. The error rates and the encoding times for each reading paragraph were also recorded as reference variables.

It was expected, first, that if Self-Referencing motivates subjects to perform better on the task, the overall performance of the Self-Referencing group would be better than that of the control group; second, that if subjects use the "You" term as a focus in organizing information, the overall performance on Position 1 and

Position 5 might be different from Position 3 for the Self-Referencing group, and furthermore, that there might be an interaction between Self-Referencing and Pair Type; third, that a standard serial position effect would be observed on adjacent pairs for the control group, whereas the serial position curve might change according to the position of the "You" term for the experimental group; and fourth, that the distance effect would be evident for the inner pairs.

Method

Subjects. Forty-eight university students (29 females and 19 males) participated in this study to fulfil requirements of their introductory psychology course. Subjects' ages ranged from 18 to 44 years with a mean of 20.58 (SD = 4.73).

Subjects were randomly assigned to experimental and control groups, with 24 subjects in each group. For the experimental group, there were 9 male students and 15 females. For the control group, there were 10 males and 14 females.

Apparatus. A computer program was designed to present the learning materials and the test stimuli. Subjects were tested on a PS/2 Model 25 computer. The computer program incorporated a timing program designed by Graves and Bradley (1988), which provided millisecond timing. According to Segalowitz and Graves (1990), the use of a PC keyboard as response panel for subjects in a reaction time task involves a mean delay of about 10 msec and a random error of $\pm$ 5 msec on a PS/2 computer. However, since the error was random, it was not a great concern of this experiment.

Materials. The learning materials were very similar to those used by Potts (1972), namely, a 5-term linear ordering relation described in a story format. Common one-syllable first names were employed as different terms in the linear ordering. To avoid a possible gender effect, tasks for female subjects included only female names, while tasks for male subjects used only male names. If a subject had the same name as any of the names used in the task, it was replaced by another one. By doing this, the possible unexpected same name factor could be eliminated.

For the experimental group, "You" was included as one of the five terms. The control group had "Bob" or "Ann" as a replacement for the "You" term for male and female subjects respectively. The tasks given to the two groups were otherwise identical. Three linear ordering relations were presented to the subjects, with the "You" term ("Bob" or "Ann" for the control group) placed at either the first, third, or fifth position. Sample tasks for the experimental group, illustrating the three linear orderings, are shown below:

> Students are voting for their leader. Tom gets more votes than John, John gets more votes than You, You get more votes Rod, and Rod gets more votes than Paul.

Here is some more information about the five people who got votes. You are taller than Tom, Tom is taller than John, John is taller than Paul, Paul is taller than Rod.

Here is another piece of information about the time these five candidates arrive for the class today. John is earlier than Paul, Paul is earlier than Rod, Rod is earlier than Tom, Tom is earlier than You.

For the female subjects, the names included in these paragraphs were Sue, Kate, Pam, and Jane. If the subject had a name that was identical to any of those given in the paragraph, "Kim" or "Dan" were used to replace the female or male name respectively. The presentation sequence of the three paragraphs remained the same for all subjects. The position of the "You" term or the control term, however, was completely counterbalanced across the three paragraphs, resulting in 6 presentation sequences of the three Position conditions (Positions 1, 3 and 5) for the three paragraphs, namely 135, 153, 315, 351, 513, 531. Subjects were randomly assigned to these different presentation sequences with 4 subjects from the experimental group and 4 from the control group in each condition.

Twenty statements about pair-wise relations were constructed for each linear ordering. These consisted of 10 correct statements (eg, Tom gets more votes than John.) and 10 false statements (e.g., John gets more votes than Tom.). These statements can be classified in terms of their truth value, the distance between the two terms (steps), and whether they involved any endpoints (See Table 1). The 20

Table 1

The 20 Questions Generated from a 5-term Linear Ordering Relation: A>B>C>D>E

Test Pairs	True/False	Step Size	Endpoints involved
A > B	T	1	A
A > C	T	2	A
A > D	T	3	A
A > E	T	4	A & E
B > C	T	1	None
B > D	T	2	None
B > E	T	3	E
C > D	T	1	None
C > E	T	2	E
D > E	T	1	E
E > D	F	1	E
E > C	F	2	E
E > B	F	3	E
E > A	F	4	A,E
D > C	F	1	None
D > B	F	2	None
D > A	F	3	A
C > B	F	1	None
C > A	F	2	A
B > A	F	1	A

questions were presented twice after the study session and the presentation sequence of the 20 questions was randomized.

A practice paragraph, as shown below, with a set of six test sentences was constructed to familiarize subjects with the task.

> In a Green forest the animals are voting for their leader. The frog gets more votes than the hawk. The hawk gets more votes than the rabbit.

Procedure. Upon arrival at the laboratory, subjects were told that this study was about information processing on a linear ordering task, and that all the necessary instructions would be given on the computer screen. Since all the instructions were programmed and subjects were tested in front of a computer, the experiment was carried out in small groups ranging from 2 to 10 subjects at a time. Each subject was assigned to a terminal where they could be tested quietly. Subjects were first required to type in their first name, age, and gender on the computer. The program was designed to decide which task to present to the subjects according to this input information.

Prior to the main session of this experiment, subjects were given a practice session. This enabled subjects to become familiar with the task. After the practice session, subjects were presented with the paragraphs one at a time. They were told to take as much time as they needed to study each paragraph and to answer the questions as quickly as possible without making errors. The testing session started right after subjects pushed a button indicating that they were ready. Two sets of 20 questions about pair-wise relations based on the information learned from the task were randomly presented to the subjects. If the statement presented was true, subjects were expected to respond "yes" by pressing a blue labelled key on the keyboard. If the statement was false, they were expected to respond "No" by pressing a red labelled key on the keyboard. Subjects were instructed to leave their fingers on the two response keys throughout the testing.

The study-test run was repeated three times, once for each of the three linear orderings. To decrease interference between tasks, subjects were asked to do 10 simple arithmetic questions after each testing session.

Results

In this experiment, subjects were given as much time as they needed to study each paragraph before answering the test questions. The amount of time they spent reading each paragraph was recorded as a reference variable. Table 2 shows the means and standard deviations for each experimental and control condition. A 2 (Self-Referencing) X 3 (Position of Self-Referencing) ANOVA was performed on the reading time variable. The main effect of Self-Referencing, $F(1, 46) = .43$, $p > .05$, and the main effect of Position, $F(2, 92) = 2.41$, $p > .05$, were both found to be

Table 2

Means and Standard Deviations of Reading Time (in seconds) as a Function of Self-Referencing and Position: Experiment 1 (N=48)

		Condition		
Position		Experimental	Control	Total
1 (A)	*M*	34.46	41.11	37.78
	SD	17.40	14.92	16.38
3 (C)	*M*	37.97	33.52	35.74
	SD	17.84	22.27	20.09
5 (E)	*M*	37.98	46.17	42.07
	SD	22.01	31.91	27.43

non-significant. The interaction of these two factors was also non-significant, $F(2, 92) = 2.74$, $p > .05$. These results eliminate encoding time as a potential explanation for any differences that were observed in the testing session.

After each reading session, 40 questions (20 questions twice each) were presented to the subjects. Table 3 shows mean error rates on these questions for each experimental and control condition. The error rates were very low (less than 10%) across all conditions. A 2 (Self-Referencing) X 3 (Position of Self-Referencing) ANOVA was applied to analyze the error rate data. The results showed that neither the main effect for Self-Referencing, $F(1, 46) = .18$, $p > .05$, nor the main effect for Position, $F(2, 92) = .07$, $p > .05$, was significant. Similarly, no significant interaction was found between these two factors, $F(2, 92) = 1.00$, $p > .05$.

The overall low error rate provided an appropriate condition for the analysis of RT. The following analyses all used RT as the dependant variable. The RT for each of the 20 pairs was calculated by applying the following steps. First, the RTs from erroneous answers were excluded from the analyses. Second, RTs that were greater than 10000 milliseconds or less than 100 milliseconds were discarded because of their unusual values. Third, since the 20 pairs were tested twice each, the average RT from the two identical test pairs was used. Approximately 1.3% of the RT

Table 3

Means and Standard Deviations of Error Rates as a Function of Self-Referencing and Position: Experiment 1 (N=48)

Position		Condition		
		Experimental	Control	Total
1 (A)	M	.083	.058	.071
	SD	.092	.079	.086
3 (C)	M	.074	.064	.069
	SD	.089	.087	.087
5 (E)	M	.060	.072	.066
	SD	.066	.084	.075

data were eliminated due to the criteria stated in step 2 above. No additional data would have been eliminated had the lower bound on acceptable RT's been raised to 250 milliseconds.

Overall performance. For each subject, the overall performance on each task was derived from the average RT for all 20 test pairs. Table 4 shows means and standard deviations of overall performance scores for each experimental condition. Figure 1 is a plot of these mean RTs as a function of Self-Referencing and Position. As shown in Figure 1, when "You" was positioned at the two ends, the Experimental group performed better than the control group. However, when "You" was positioned at the third (middle) position, the control group outperformed the Self-Referencing group.

A 2 (Self-Referencing) X 3 (Position of Self-Referencing) ANOVA was applied to test the significance of these observations. Table 5 shows the results of this analysis. As indicated in Table 5, there was a significant Position effect, $F(2, 92) = 4.06$, $p < .020$. Although the Self-Referencing main effect was non-significant, $F(1, 46) = .84$, $p > .05$; the interaction between Self-Referencing and Position was highly significant, $F(2, 92) = 7.58$, $p < .001$.

To guard against violation of the sphericity (homogeneity of covariance) assumption for within-subjects variables in a randomized block design, the significant F

Table 4

Means and Standard Deviations of RT (in milliseconds) for all 20 Pairs as a Function of Self-Referencing and Position: Experiment 1 (N=48)

		Condition		
Position		Experimental	Control	Total
1 (A)	*M*	2695.96	2996.42	2846.19
	SD	765.47	761.93	770.64
3 (C)	*M*	3135.20	2879.65	3007.42
	SD	636.06	638.59	643.60
5 (E)	*M*	2553.46	2951.08	2752.27
	SD	500.16	646.66	606.15

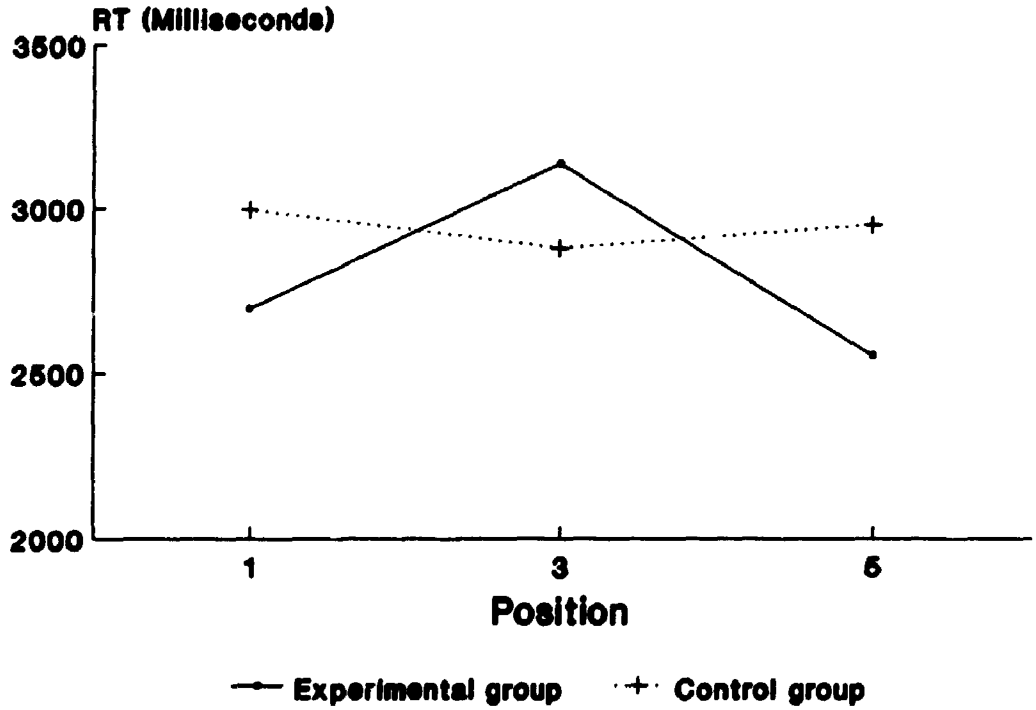


Figure 1. Overall performance: Mean RT for all 20 test pairs as a function of Self-Referencing and Position in Experiment 1.

Table 5

2 (Self-Referencing) X 3 (Position of Self-Referencing) ANOVA Table: Experiment 1

Dependent Variable: Mean RT from all 20 pairs

Independent Variables:

Between Factor (A) --- Self-Referencing

A_1 - Experimental Group
A_2 - Control Group

Within Factor (B) ---- Position of Self-Referencing

B_1 - Position 1
B_2 - Position 3
B_3 - Position 5

SOURCE	SS	DF	MS	F	P
between					
A	783380.72	1	783380.22	.84	.364
S(A)	42791648.20	46	930253.22		
within					
B	1598723.69	2	799361.84	4.06*	.020
AB	2980807.15	2	1490403.60	7.58*	.001
AS(A)	18093530.69	92	196668.81		
Pooled	60885178.19	138	441196.94	[S(A) & BS(A)]	
A at B_1	1083355.95	1	1083355.95	2.46[a]	
A at B_2	783616.28	1	783616.28	1.78	
A at B_3	1897215.64	1	1897215.64	4.30	
B at A_1	4413189.38	2	2206594.70	11.22*[b]	
B at A_2	166341.46	2	83170.73	.42	

Note. $^{a}F_{.15/5;1,85} = 5.5$
$^{b}F_{.15/5;2,92} = 4$

statistics were further evaluated using an adjusted *F* test, known as the Box correction (Kirk, 1982; Keppel, 1991). The adjusted *F* test adjusts numerator and denominator degrees of freedom by a factor that reflects the degree of heterogeneity of covariance actually present in an experiment. This procedure was carried out in the present analysis and through all subsequent analyses reported in this paper. It was found that all significant conventional *F* tests remained significant with the adjusted *F* test. For the sake of simplicity, however, only the conventional degrees of freedoms are reported in this paper.

Further analyses on the simple effects of Self-Referencing and Position were carried out to help understand the nature of the significant interaction between Self-Referencing and Position. In the analyses of simple effects, the Type I error was controlled via Dunn's Procedure. In addition, Satterthwaite's (1946) method was applied to estimate the degrees of freedom for the pooled error terms. These same procedures were used in the analyses of simple main effects in all three experiments.

As shown in Table 5, the simple main effects of Self-Referencing at all three different positions were non-significant. However, results on the simple main effects of Position showed a significant effect for the experimental group, $F(2, 92) = 11.22$, but not for the control group, $F(2, 92) = .42$.

The Scheffé S test was used to contrast the three means in the "You" group. The results showed that when the "You" term was at the first and last positions, subjects performed significantly better than when the "You" term was at the middle position, F=14.24 ($2F_{.05;2,92} = 6.3$).

Self-Reference vs. Other pair types. Due to the nature of the task, the 20 pair comparisons presented after each paragraph could be classified into two types. One type of pair had a "You" term involved (e.g., You are taller than John), and the other type of pair did not have a "You" term involved (e.g., John is taller than Tom). These two types were designated as Self-Reference Pairs and Other Pairs respectively.

It should be noted that the Position effect was confounded with the types of pairs selected at each position. For example, when "You" was at position 1 the Self-reference Pairs consisted of pair types AB, AC, AD, and AE; whereas when "You" was at position 3 the Self-reference Pairs involved pairs AC, BC, CD, and CE (See Table 6). Therefore, it is not appropriate to interpret the Position effect in the following tests. However, since the pairs chosen from each position were the same for the experimental and control conditions, it was proper to examine the Self-Referencing effect.

Table 7 gives means and standard deviations for each condition. Figure 2 is a plot of mean RTs for Self-

Table 6

Pairs with a "You" term (Marked with a X) as a Function of Position: Experiment 1

	Position		
Test Pairs	1(A)	3(C)	5(E)
A > B	X		
A > C	X	X	
A > D	X		
A > E	X		X
B > C		X	
B > D			
B > E			X
C > D		X	
C > E		X	X
D > E			X
E > D			X
E > C		X	X
E > B			X
E > A	X		X
D > C		X	
D > B			
D > A	X		
C > B		X	
C > A	X	X	
B > A	X		

Table 7

Means and Standard Deviations of RT (in Milliseconds) for Self-Reference Pairs and Other Pairs as a Function of Self-Referencing, and Position: Experiment 1 (N = 48)

		Condition		
Position		Experimental	Control	Total
1 (A)				
Self-Reference Pairs	M	2083.81	2622.95	2353.38
	SD	700.65	802.76	793.60
Other Pairs	M	3115.59	3249.76	3182.67
	SD	929.68	894.49	905.04
3 (C)				
Self-Reference Pairs	M	2969.53	3033.02	3001.28
	SD	709.72	687.14	691.79
Other Pairs	M	3249.83	2779.25	3014.54
	SD	706.36	664.56	718.91
5 (E)				
Self-Reference Pairs	M	1847.57	2874.38	2360.98
	SD	380.14	925.87	871.44
Other Pairs	M	3020.74	3006.41	3013.57
	SD	647.20	587.46	611.49

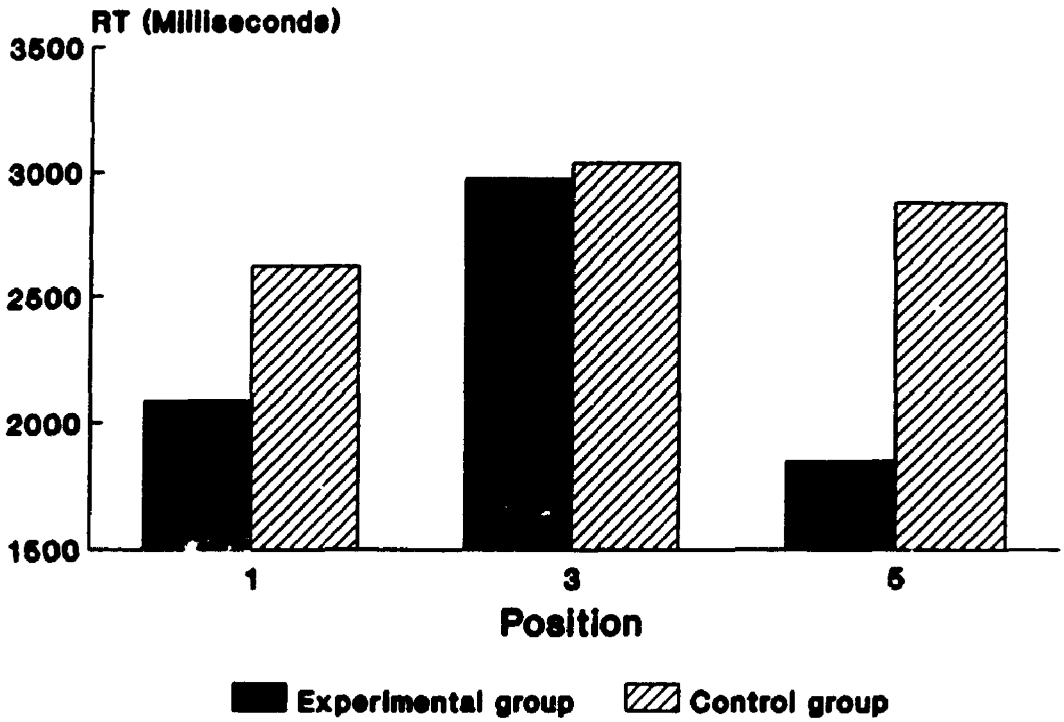


Figure 2. Mean RT for Self-Reference pairs as a function of Self-Referencing and Position in Experiment 1.

Reference Pairs, whereas Figure 3 is a plot of mean RTs for Other Pairs. As shown in Figure 2, the experimental group performed uniformly better than the Control group on the Self-reference Pairs. However, as indicated in Figure 3, comparison of performance on the Other Pairs did not show the same uniform trend. When "You" was positioned first or last, subjects in the experimental group performed equal to or slightly better than the control group on Other Pairs. With "You" at the middle (third) position, however, the "You" group performed more poorly than the control group.

A 2 (Self-Referencing) X 3 (Position of Self-Referencing) X 2 (Pair Type) ANOVA was applied to examine these data. As shown in Table 8, though the main effect of Self-Referencing was not significant, there was a significant two way interaction between Self-Referencing and Pair Type, $\underline{F}(1, 46) = 28.98$, $\underline{p} < .001$. A significant three way interaction was also obtained, $\underline{F}(2, 92) = 3.81$, $\underline{p} < .026$.

The simple main effects of Self-Referencing at different levels of Position and Pair Type were further examined. As shown in Table 8, two simple main effects were found to be significant. When the "You" term was at the first and fifth position, the Self-Referencing group performed better than the control group on the Self-Reference Pairs, $\underline{F}(1, 127) = 6.46$, and $\underline{F}(1, 127) = 23.43$ respectively. In other words, when the "You" term was

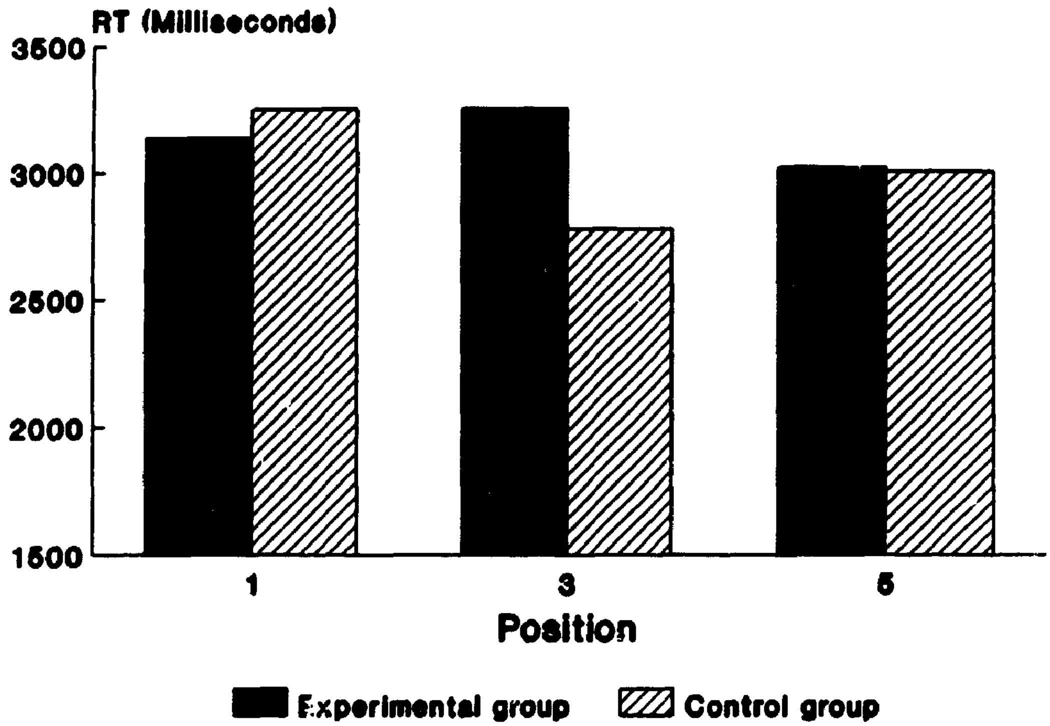


Figure 3. Mean RT for the Other pairs as a function of Self-Referencing and Position in Experiment 1.

Table 8

2 (Self-Referencing) X 3 (Position of Self-Referencing) X 2 (Pair Type) ANOVA Table: Experiment 1

Dependant Variable: Mean RT

Independent Variables:

Between Factor (A) --- Self-Referencing

A_1 - Experimental Group
A_2 - Control Group

Within Factor (B) ---- Position of Self-Referencing

B_1 - Position 1
B_2 - Position 3
B_3 - Position 5

Within Factor (C) --- Pair Type

C_1 - Self-Reference Pairs
C_2 - Other Pairs

SOURCE	SS	DF	MS	F	P
between					
A	3270170.10	1	3270170.10	1.78	.188
S(A)	84393275.57	46	1834636.4		
within					
B	5339766.48	2	2669883.2	6.85*	.002
AB	6594954.73	2	3297477.4	8.46*	.000
BS(A)	35860999.30	92	389793.47		
C	17883920.99	1	17883920.99	66.10*	.000
AC	7842439.26	1	7842439.26	28.98*	.000
CS(A)	12446291.65	46	270571.56		
BC	8847057.89	2	4423528.9	24.84*	.000
ABC	1356930.36	2	678463.18	3.81*	.026
BCS(A)	16382972.45	92	178075.79		
Pooled	149083538.97	276	540157.75	(all 4 error terms)	
A at B_1C_1	3488161.22	1	3488161.22	6.46*a	
A at B_2C_1	48383.60	1	48383.60	.09	
A at B_3C_1	12656074.36	1	12656074.36	23.43*	
A at B_1C_2	215998.02	1	215998.02	.40	
A at B_2C_2	2657413.50	1	2657413.50	4.92	
A at B_3C_2	2463.77	1	2463.77	.00	

Note. $^aF_{.20/6;1,127} = 5.4$

positioned at the two ends, subjects performed better on those test pairs where "You" was involved. However, this superior performance did not carry over to the middle position nor did it carry over to other pairs.

Serial position and endpoint effects. For each adjacent pair, the RTs for the true and false statements were averaged. There were four serial positions in the test (A-B, B-C, C-D, D-E). If the two ends showed a shorter RT, a normal serial position effect would be evident. Table 9 gives the means and standard deviations of RTs for each experimental and control condition.

As may be noted in Table 10, a 2 (Self-Referencing) X 3 (Position of Self-Referencing) X 4 (Serial Position) ANOVA indicated a significant Serial Position main effect, $F(3, 120) = 13.31$, $p < .001$. Significant two-way interactions were found between Self-Referencing and Position of Self-Referencing, $F(2, 80) = 3.23$, $p < .045$, and between Position of Self-Referencing and Serial Position, $F(6, 420) = 4.80$, $p < .001$. The three way interaction was also found to be significant, $F(6, 240) = 2.66$, $p < .016$.

The best way to examine the serial position effect would be to visually inspect the serial position curve. For the control group, the five conditions were pooled. As shown in Figure 4, a serial position effect with a bias toward the A end was evident. Subjects were fastest in answering the A-B pair, followed by the D-E pair. The B-C

Table 9

Means and Standard Deviations of RT (in milliseconds) for Adjacent Pairs as a Function of Self-Referencing, and Position: Experiment 1 (N = 42)

		Serial Position			
Position		A-B	B-C	C-D	D-E
1 (A)					
Experimental[a]					
	M	2215.20	3217.84	3576.81	3094.44
	SD	1018.85	1115.13	1300.13	1646.60
Control[b]					
	M	2579.59	3254.32	3208.95	3151.10
	SD	1053.30	980.12	1016.69	1191.44
3 (C)					
Experimental					
	M	2841.78	3107.55	3111.16	3768.40
	SD	1006.27	1145.74	1008.01	1144.48
Control					
	M	2486.42	2878.49	3541.61	3001.58
	SD	779.46	868.90	1187.20	984.83
5 (E)					
Experimental					
	M	2615.77	3490.99	3224.81	2284.51
	SD	1081.15	1276.81	960.75	766.54
Control					
	M	2639.12	3235.26	3392.91	2917.73
	SD	1041.96	971.44	870.54	1044.86

Note. [a] n = 21
[b] n = 21

Table 10

2 (Self-Referencing) X 3 (Position of Self-Referencing) X 4 (Serial Position) ANOVA Table: Experiment 1

Dependant Variable: Mean RT

Independent Variables:

Between Factor (A) --- Self-Referencing

A_1 - Experimental Group
A_2 - Control Group

Within Factor (B) ---- Position of Self-Referencing

B_1 - Position 1
B_2 - Position 3
B_3 - Position 5

Within Factor (C) --- Serial Position

C_1 - A-B
C_2 - B-C
C_3 - C-D
C_4 - D-E

SOURCE	SS	DF	MS	F	P
between					
A	488351.25	1	488351.25	.11	.742
S(A)	177833113.5	40	4445827.8		
within					
B	1256314.27	2	628157.13	.55	.579
AB	1256314.27	2	3695698.0	3.23*	.045
BS(A)	91419191.89	80	1142739.9		
C	35028586.98	3	11676196	13.31*	.000
AC	1388369.04	3	462789.68	.53	.664
CS(A)	105304356.9	120	877536.31		
BC	20000869.21	6	3333478.2	4.80*	.000
ABC	11101406.51	6	1850234.4	2.66*	.016
BCS(A)	166678122.2	240	694492.18		

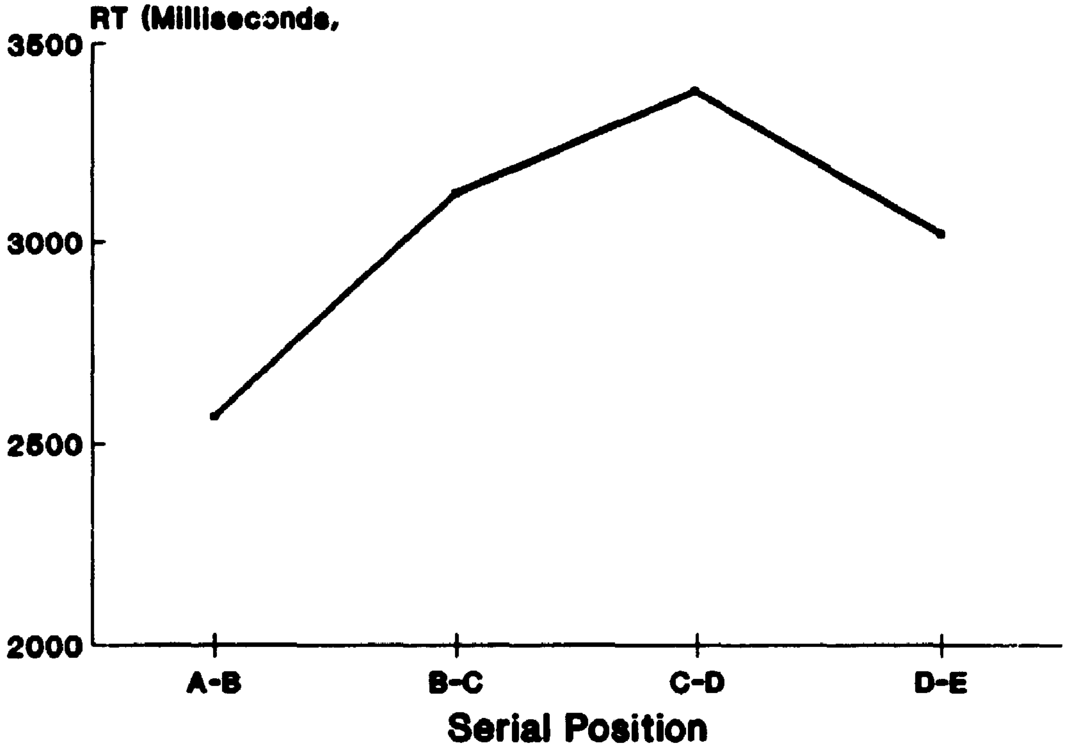


Figure 4. Serial position effect for the Control group: Mean RT for adjacent pairs as a function of serial position in Experiment 1.

pair was the third fastest, and the C-D pair was the slowest.

Using the serial position curve from the control group as a comparison, it may be seen in Figures 5, 6, and 7 that, the serial position curve for the Self-Referencing group changed according to the position of the "You" term. As indicated in Figure 5, when the "You" term was at the first position, the first endpoint effect (A) was more salient. On the other hand, when the "You" term was placed at E position, the E endpoint effect becomes the strongest (See Figure 7). Most particularly, when the "You" term was at the third position, as shown in Figure 6, the A end effect became minor and the E endpoint effect was reversed.

Distance effect. With a control on endpoint effects, the distance effect was tested using the 6 inner pairs, among which two types of test pairs were classified: 1-step (adjacent) pairs and 2-step (remote) pairs.

Table 11 shows means and standard deviations for 1-step and 2-step pairs in each experimental and control condition. As shown in Figure 8 and 9, most of the means do not support the predicted direction. For the control group, only at position 5 were the 2-step pairs faster than the 1-step pairs. For the experimental group, the 2-step pairs were faster than the 1-step pairs only when "You" was at the first position.

Table 12 shows results from a 2 (Self-Referencing) X 3

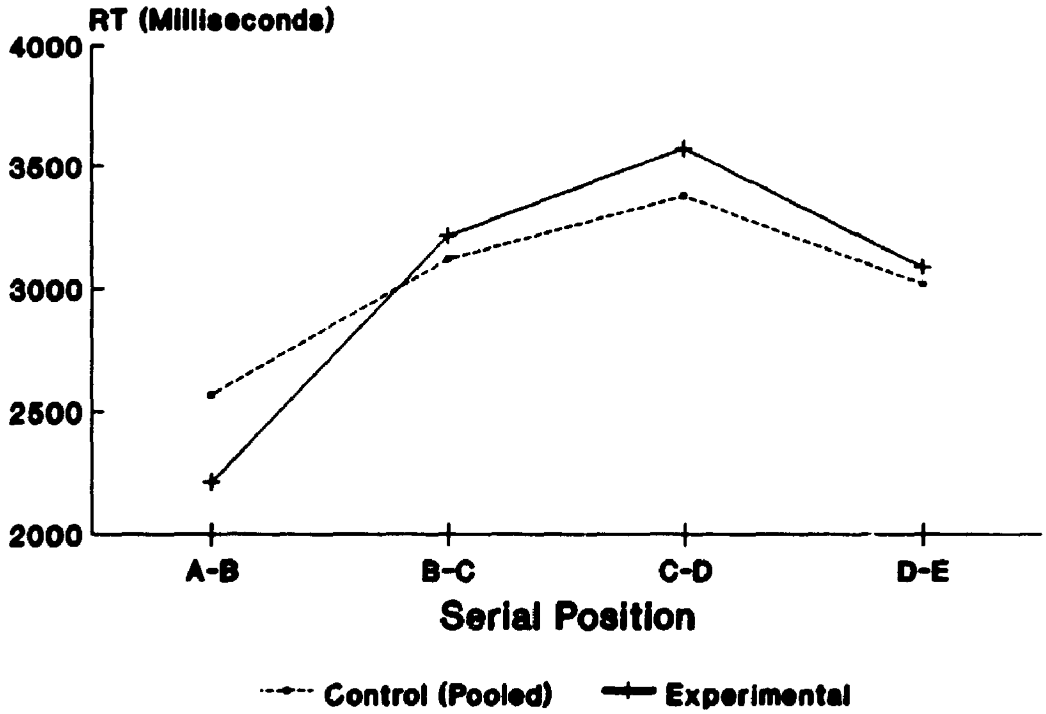


Figure 5. Serial position effect for the Experimental group with "You" term in Position 1 (A): Mean RT for adjacent pairs as a function of serial position in Experiment 1.

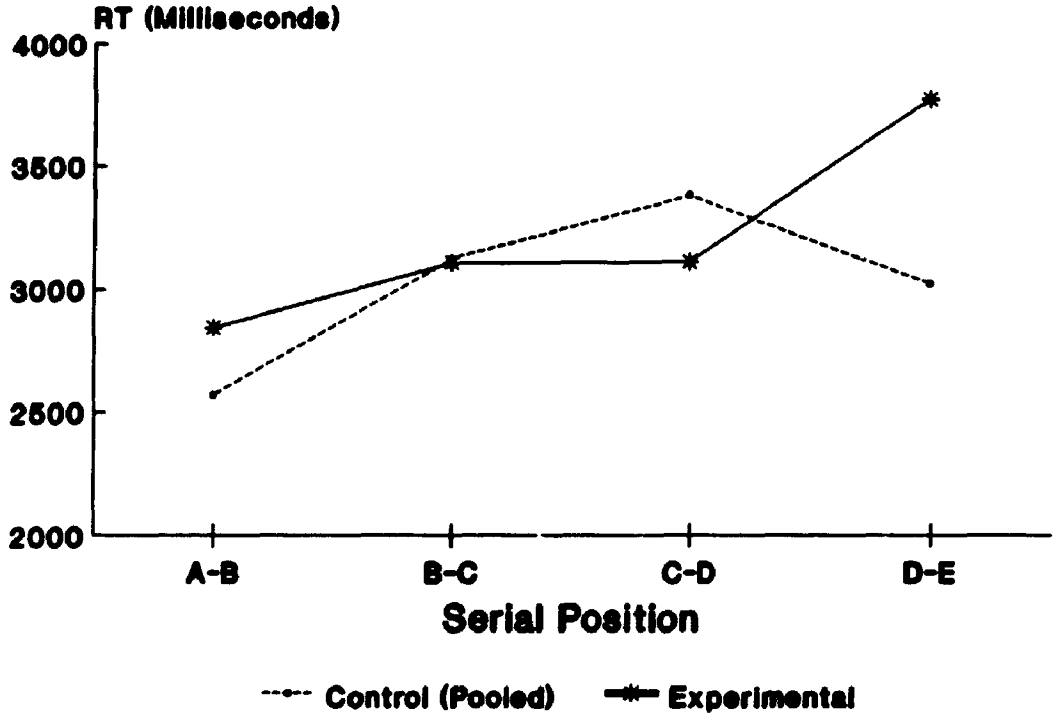


Figure 6. Serial position effect for the Experimental group with "You" term in Position 3 (C): Mean RT for adjacent pairs as a function of serial position in Experiment 1.

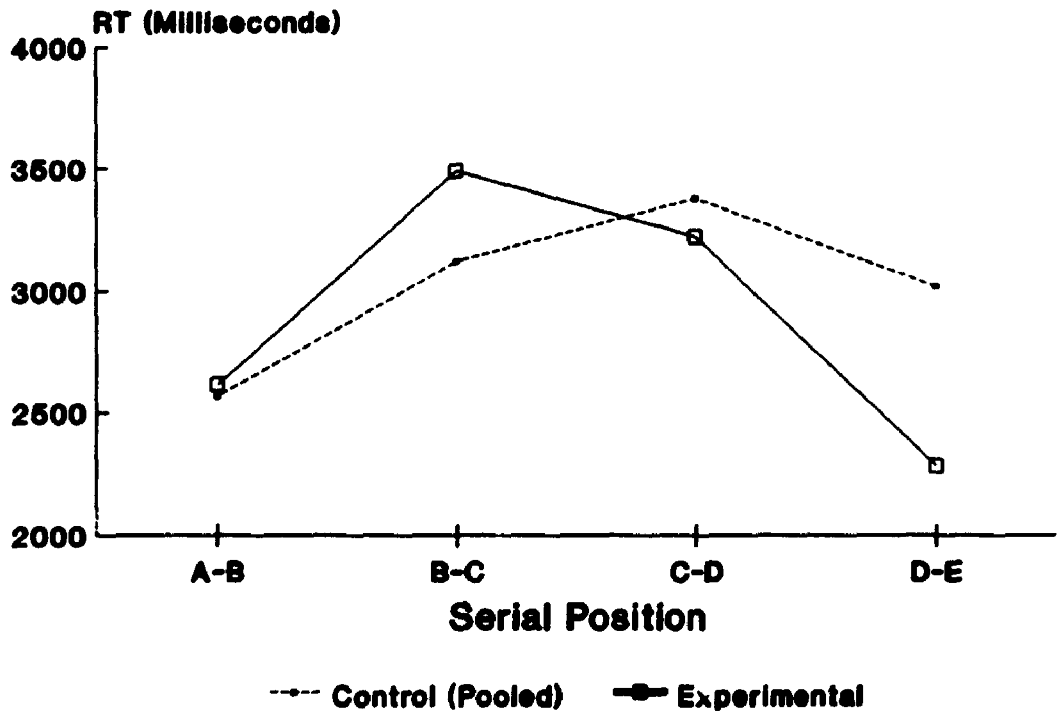


Figure 7. Serial position effect for the Experimental group with "You" term in Position 5 (E): Mean RT for adjacent pairs as a function of serial position in Experiment 1.

Table 11

<u>Means and Standard Deviations of RT (in milliseconds) for 1-step and 2-step Inner Pairs as a Function of Self-Referencing and Position: Experiment 1 (N = 48)</u>

	Condition		
Position	Experimental	Control	Total
1 (A)			
1-Step Pairs			
M	3361.40	3234.48	3297.94
SD	1116.56	845.48	981.56
2-Step Pairs			
M	3170.37	3450.04	3310.20
SD	923.98	1164.52	1049.47
3 (C)			
1-Step Pairs			
M	3102.29	3211.70	3156.99
SD	803.34	853.25	821.67
2-Step Pairs			
M	3636.79	3394.30	3515.55
SD	1516.08	1475.18	1484.83
5 (E)			
1-Step Pairs			
M	3355.30	3315.91	3335.61
SD	903.69	669.04	786.82
2-Step Pairs			
M	3404.49	3232.31	3318.40
SD	1122.05	888.18	1004.84

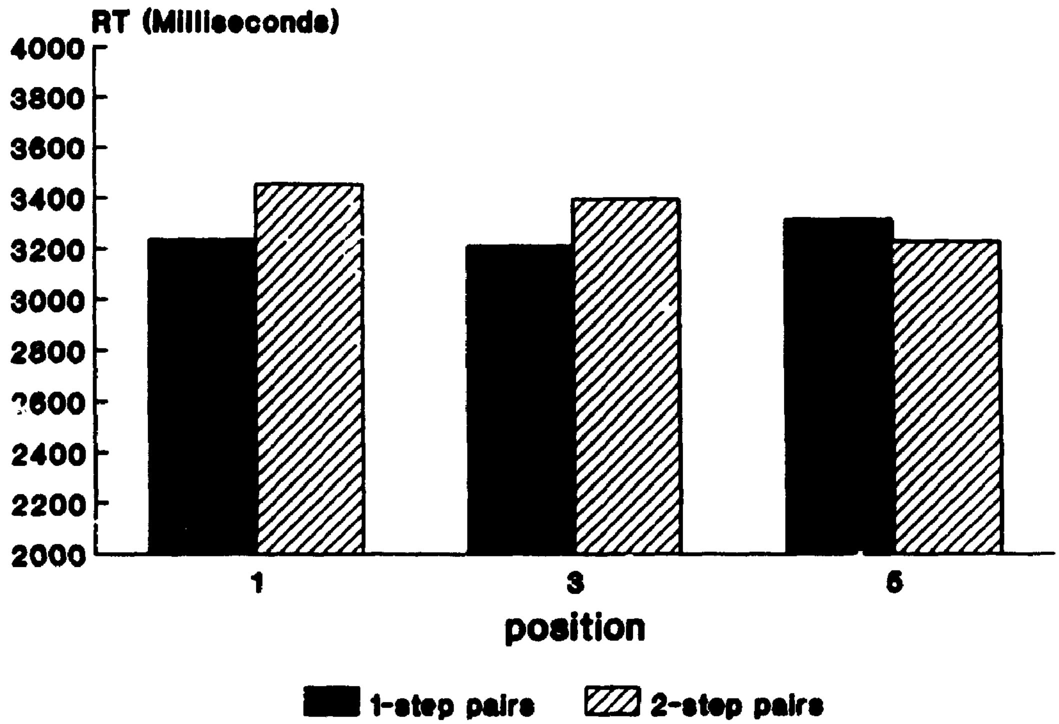


Figure 8. Distance effect for the Control group: Mean RT for 1-step and 2-step pairs as a function of Position in Experiment 1.

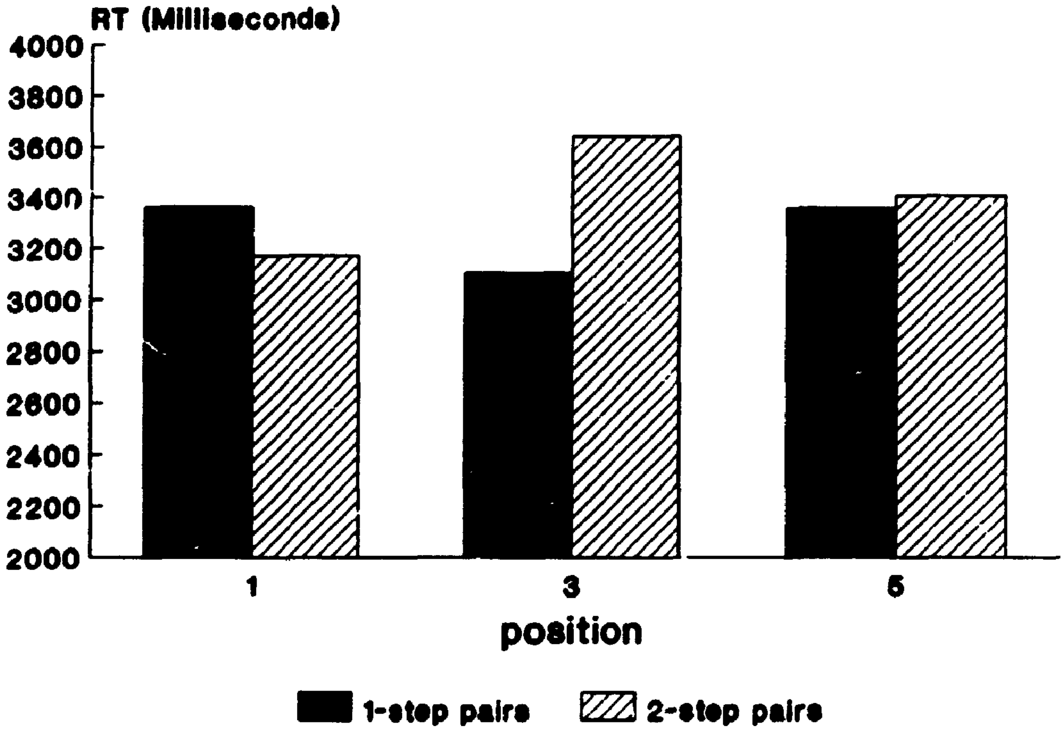


Figure 9. Distance effect for the Experimental group: Mean RT for 1-step and 2-step pairs as a function of Position in Experiment 1.

Table 12

2 (Self-Referencing) X 3 (Position of Self-Referencing) X 2 (Distance) ANOVA Table: Experiment 1

Dependant Variable: Mean RT

Independent Variables:

Between Factor (A) --- Self-Referencing

A_1 - Experimental Group
A_2 - Control Group

Within Factor (B) ---- Position of Self-Referencing

B_1 - Position 1
B_2 - Position 3
B_3 - Position 5

Within Factor (C) --- Distance

C_1 - 1-Step Pairs
C_2 - 2-Step Pairs

SOURCE	SS	DF	MS	F	P
between					
A	73638.69	1	73638.69	.03	.856
S(A)	101705289.69	46	2210984.6		
within					
B	52748.41	2	26374.21	.02	.973
AB	441210.64	2	220605.32	.18	.836
BS(A)	113219023.9	92	1230641.21		
C	1000331.45	1	1000331.45	1.10	.299
AC	12197.81	1	12197.81	.01	.908
CS(A)	41747660.35	46	907557.83		
BC	2095856.50	2	1047928.3	1.93	.151
ABC	1828492.87	2	914246.43	1.68	.191
BCS(A)	49953559.96	92	542973.48		

(Position of Self-Referencing) X 2 (Distance) ANOVA. There were no main effects or interactions found to be significant.

Discussion

This study does not support the expectation that including a self reference ("You") term in a linear ordering task motivates people to perform generally better on all components of the task. Though there was a significant interaction between Self-Referencing and Position, further analysis of the simple main effects of Self-Referencing showed no significant difference in overall performance between the experimental and control groups at any of the three self-referencing positions.

Though the data do not reveal a general performance advantage of self-referencing in the task, various cognitive effects of self-referencing are evident in the results. For example, the expectation that performance on Position 1 and Position 5 will be different from Position 3 for the Self-Referencing group was supported. The analyses of the simple main effect of Position indicated a significant effect of this factor on the Self-Referencing group. For the Self-Referencing group, positioning the "You" term at the two ends resulted in significantly better overall performance than did positioning "You" in the middle.

In the Introduction, two competing hypotheses concerning the Position effect were proposed. One is that when the "You" term is placed at positions other than the two ends, it provides subjects an extra focus, and therefore facilitates performance. The other hypothesis is placing the "You" term at positions other than the two ends causes subjects to lose some degree of the facilitative effect of end anchors. The results of the present experiment provide tentative support for the latter theory. That is, placing the "You" term at Position 3 results in significantly worse performance than placing "You" at the two ends. This Position effect on overall performance is clearly illustrated in Figure 1, where the RTs for the experimental group in the three self-referencing positions showed an inverted V trend.

Further evidence of indirect cognitive effects of self-referencing is provided by the significant interaction between Self-Referencing and Pair Type. When the "You" term was at the two end positions, the experimental group responded significantly faster than the control group on test pairs involving a "You" term (Self-Reference Pairs), but not on the test pairs involving no "You" term (Other Pairs). One possible interpretation of this result is that subjects focused more and gave priority to self-relevant information, and therefore, less attention or priority was given to the other type of information.

Thus, the findings from this experiment imply that self referencing has a significant but complex cognitive effect.

When there is a "You" term involved, subjects seem to use a self-focusing strategy in organizing information. By using the third term as a focus, the advantage of the two end anchors is deteriorated. The theory on the use of self-focusing strategy is further supported in the tests of endpoint effect.

As predicted, the endpoint effect is evident only for the control group. The serial position curve for the control group shows that the test pairs from the two ends have a shorter RT than those in the middle. For the experimental group, on the other hand, the serial position curve varies according the position of the "You" term. When the "You" term is at first position, the A endpoint effect is stronger. Similarly, when "You" is at the fifth position, the E endpoint effect becomes more robust. Having a "You" term at the middle, however, diminishes the normal endpoint effects. These observations coincide with the hypothesis. It also provides strong support to the theory that people use the "You" term as a focus point in organizing information.

Results from the present experiment showed strong evidence that the "You" term in the linear ordering task directed a focus shift. From an educational point of view, this finding implies that referring to students in personalized terms appears to be a good way to direct their attention and change their cognitive processing. However, it is not clear whether such self-referencing processes occurred in all the subjects in the present experiment. Since the relational description in the task was artificial in nature, it is very possible that there were individual differences in subjects' responses to the "You" term. In other words, whether all experimental subjects actually referred the "You" term to themselves remains a question. Given that the "You" term was distinctively different from the other proper names used in the linear ordering task, it is possible that its distinctive nature rather than its self-referencing properties encouraged subjects to use it as a focus in organizing information. In other words, it is possible that the theoretical mechanism underlying the focus shift is "distinctiveness" rather than "self-referencing". The exact nature of the mechanism underlying the self-referencing effect is beyond the scope of the present research. Also, this issue is of limited relevance from an applied or educational point of view, because self-referencing can be put into action in the classroom in purely operational terms, without a full understanding of its theoretical basis. However, as a first step in providing data on the above questions, Experiment 2 (below) included descriptive self-reports from subjects on their cognitive reactions to the linear ordering task.

Finally, one surprising finding of this study was the absence of the predicted distance effect. The expectation that subjects would be faster for 2-step inner pairs than for 1-step inner pairs was not supported. The data show that distance did not pla a significant role in determining RT for inner pairs. This observation is contradictory to previous findings.

In short, the results of the present experiment seems to suggest that including a "You" term in a linear ordering task does not necessarily lead to a generalized increase in subjects' motivation to perform the task. Instead, subjects appear to process and organize information in a qualitatively different way as a result of self-referencing, using the "You" term as a focus. There is, however, a concern about the power of the tests in the present experiment, particularly on the main effect of Self-Referencing. It will be recalled that Self-Referencing was a between-subjects factor in the present experiment. As Kirk (1982) pointed out, the power of the tests for the within-subjects factor is greater than for the between-subjects factor in a split-plot design. It is possible that the non-significant findings for the Self-Referencing factor were due in part to lack of adequate power of statistical tests.

Experiment 2

The purpose of Experiment 2 was first, to replicate the findings of Experiment 1 and second, to extend the investigation to all 5 positions in the 5-term linear ordering. Thus, the major variation from Experiment 1 was that the Position of Self-Referencing had 5 levels instead of 3 levels. This made it possible to examine the effects of positioning the "You" term in all possible locations in a 5-term linear ordering. Moreover, since there was a concern about the power of statistical tests in Experiment 1, the present experiment included more subjects in each condition. After a power analysis, the number of subjects in each cell was set at 30 in this experiment.

As in Experiment 1, Self-Referencing was a between-subjects factor. Half of the subjects were randomly assigned to the Self-Referencing group and half to the Control group. Again, Position of Self-Referencing was a within- subjects manipulation, each subject going through five different tasks with "You" placed at five different positions: Position 1 (A), Position 2 (B), Position 3 (C), Position 4 (D), and Position 5(E).

The main dependent variable was RT tc test pairs. Error rates and encoding times for each reading paragraph were also recorded as reference variables. Moreover, post-experimental interview questions were presented to subjects to collect some descriptive self-report data about subjects' cognitive processing.

Method

Subjects. Sixty students, consisting of 12 males and 48 females from the Psycholog 20 subject pool participated in this experiment. Subjects were randomly assigned to the control and experimental group, with 6 males and 24 females in each group. The mean age of the subjects was 19.33 (SD = 1.59)

Apparatus. A computer program was designed to present the learning materials and the test stimuli. Subjects were tested on a PS/2 Model 25 computer. The computer program incorporated a millisecond timing program designed by Graves and Bradley (1988).

Materials. The learning materials were similar to those used in the previous experiment. Five linear ordering tasks were presented to the subjects, in which the "You" term was placed at the first, second, third, fourth, or fifth position. Sample tasks for the experimental group, illustrating the five linear orderings, are shown below:

> Students are voting for a representative. There are 5 candidates. Among these 5 individuals, Tom is older than John, John is older than You, You are older than Paul, and Paul is older than Rod.
>
> Here is some more information about the 5 candidates. John is taller than Rod, Rod is taller than Tom, Tom is taller than You, You are taller than Paul.
>
> Let's also compare theses 5 candidates on their shoe sizes. Paul is bigger than You, You are bigger than Rod, Rod is bigger than John, and John is bigger than Tom.

> We can also compare these 5 people in terms of their arm length. You are longer than Tom, Tom is longer than Paul, Paul is longer than Rod, and Rod is longer than John.
>
> Finally, we also have information available for the running speed of these 5 individuals. Rod is faster than Paul, Paul is faster than John, John is faster than Tom, and Tom is faster than You.

For the female subjects, the names included in these paragraphs were Sue, Kate, Pam, and Jane. The presentation sequence of the five paragraphs remained the same for all subjects. The position of the "You" term among the other names, however, was counterbalanced across the five paragraphs via a Latin Square design. The control group received exactly the same paragraphs as the experimental group, except that the "You" term was replaced by "Bob" or "Ann". If the subject had a name that was identical to any of those given in the paragraph, "Kim" and "Dan" were used to replace the female or male name respectively.

Twenty questions about pair-wise relations were constructed for each linear ordering. These questions consisted of 10 correct statements (e.g., You are older than John) and 10 false statements (e.g., John is older than you.). Since there were 5 tasks in the present experiment, the 20 questions were only tested once for each task to prevent excessive fatigue.

As in the first experiment, a practice paragraph with a set of six test sentences was constructed to familiarize subjects with the task. Moreover, two questions were constructed to obtain feedback from subjects about their cognitive processing. For both experimental and control groups, subjects were asked to describe the strategies they used when doing the task. The question was presented to the subjects on the computer screen as "Did you use any special strategies to memorize the ordering of the names?" Subjects in the experimental group were also asked whether they interpreted the "You" term as referring directly to themselves or not. The questions were "Did you refer the "You" term as yourself or just treat it as another name?" and "Did the "You" term in any way affect the way you memorized the names?"

Procedure. The procedures used in this experiment were identical to those of the previous experiment except that there were 5 study-test runs rather than 3. In addition, after each testing session, subjects were asked to list the names according to the ordering that they used when answering the questions. At the end of the experiment, subjects were asked to give self-report data about their cognitive processing. Answers were typed in by the subjects using the keyboard attached to the computer. Between the tasks, 10 simple arithmetic questions were presented to the subjects to decrease the interference from the previous task.

Results

The amount of time subjects spent on reading each paragraph was recorded as a reference variable. Table 13 shows the means and standard deviations of reading times for each condition. A 2 (Self-Referencing) X 5 (Position of Self-Referencing) ANOVA was performed using reading time as the dependent variable. It was found that both of the main effects were non-significant, $F(1, 58) = .74$, $p > .05$, and $F(4, 232) = 1.49$, $p > .05$, respectively. The interaction was also non-significant, $F(4, 232) = .80$, $p > .05$. These results excluded encoding times as an explanation for any differences observed in the testing session.

After each reading session, 20 questions were presented to the subjects. Table 14 shows the mean error rates for all experimental and control conditions. All error rates appeared to be low (less than 10%). A 2 (Self-Referencing) X 5 (Position of Self-Referencing) ANOVA was carried out on these data. The results showed that neither the main effect of Self-Referencing, $F(1, 58) = 2.68$, $p > .05$, nor the main effect of Position $F(4, 232) = .26$, $p > .05$ was significant. The interaction between these two factors was also not significant, $F(4, 232) = .46$, $p > .05$.

Since the error rates were low in this experiment, it was appropriate to analyze the RT data. The RT for each of the 20 pairs was calculated using the same steps applied in the first experiment, except that no averaging was

Table 13

Means and Standard Deviations of Reading Time (in Seconds) as a Function of Self-Referencing and Position: Experiment 2 (N = 60)

		Condition		
Position		Experimental	Control	Total
1 (A)	M	29.21	29.49	29.35
	SD	14.23	14.41	14.21
2 (B)	M	34.26	29.63	31.95
	SD	22.38	16.82	19.76
3 (C)	M	35.82	33.39	34.60
	SD	22.01	21.50	20.54
4 (D)	M	34.61	27.42	31.01
	SD	22.73	15.96	19.81
5 (E)	M	33.04	30.69	31.87
	SD	16.35	15.36	15.77
Total	M	31.13	30.09	30.61
	SD	12.98	13.35	13.06

Table 14

Means and Standard Deviations of Error Rates as a Function of Self-Referencing and Position: Experiment 2 (N=60)

		Condition		
Position		Experimental	Control	Total
1 (A)	*M*	.042	.085	.063
	SD	.079	.085	.089
2 (B)	*M*	.045	.068	.057
	SD	.059	.100	.083
3 (C)	*M*	.060	.072	.066
	SD	.072	.099	.086
4 (D)	*M*	.058	.075	.067
	SD	.112	.098	.105
5 (E)	*M*	.052	.058	.055
	SD	.068	.080	.073
Total	*M*	.051	.072	.062
	SD	.045	.052	.050

necessary, since the 20 questions were tested only once each in this experiment. Approximately 1.4% of RT data were excluded from the analysis due to unusually high or low RTs. No additional data would have been eliminated had the lower bound on acceptable RT's been raised to 250 milliseconds.

Overall performance. Overall performance on the task was obtained by averaging RT for all 20 test pairs. Table 15 shows means and standard deviations of overall performance in each control and experimental condition. As shown in Figure 10, when "You" was at the first, second, forth, and fifth positions, the overall performance in the "You" group was slightly better than the control group. However, when "You" was at the third position, the control group outperformed the experimental group.

For the experimental group, the performance on the five positions in order showed an inverted V trend, similar to that found in Experiment 1. When "You" was placed at the two ends, the overall performance was best, followed by the conditions where "You" was placed at the second or fourth position. When "You" was at the middle or third position, performance was worst.

A 2 (Self-Referencing) X 5 (Position of Self-Referencing) ANOVA was used to analyze these data. Table 16 gives the results of this analysis. As indicated in Table

Table 15

Means and standard deviations of RT (in milliseconds) for All 20 questions as a Function of Self-Referencing and Position: Experiment 2 (N=60)

		Condition		
Position		Experimental	Control	Total
1 (A)	M	2895.11	3156.17	3025.64
	SD	817.21	940.59	883.42
2 (B)	M	3067.40	3231.62	3149.51
	SD	766.61	1173.62	986.27
3 (C)	M	3385.80	3185.95	3285.87
	SD	1018.32	1051.69	1031.26
4 (D)	M	3022.18	3105.59	3063.89
	SD	697.25	820.43	756.02
5 (D)	M	2903.27	2922.36	2912.82
	SD	622.24	888.02	760.27
Total	M	3054.75	3120.34	3087.55
	SD	691.74	858.27	773.54

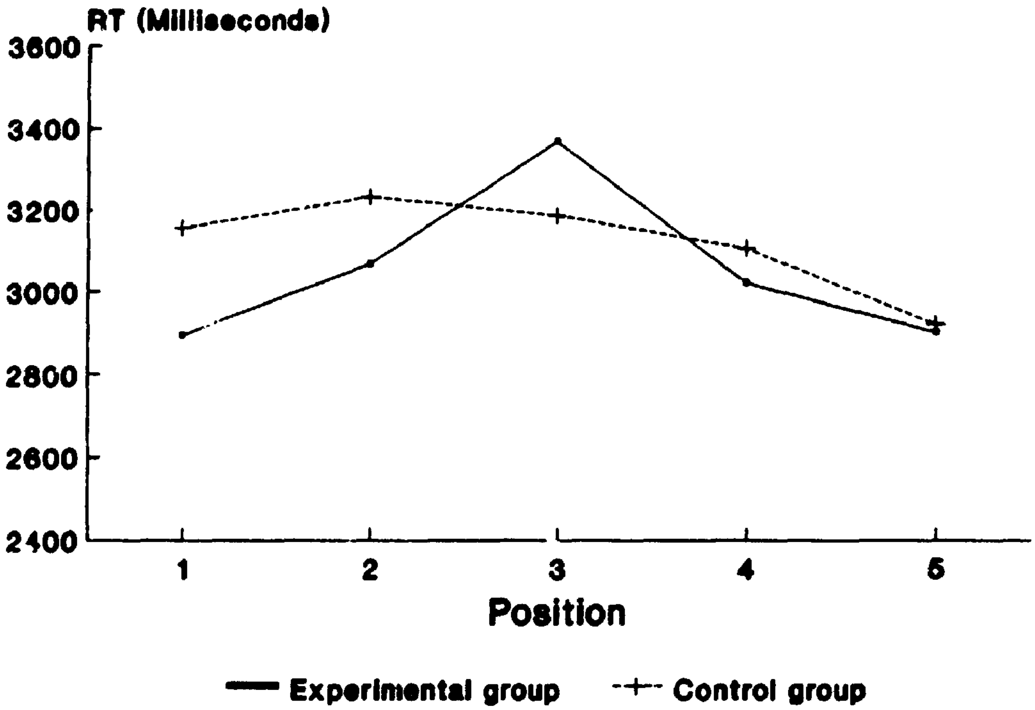


Figure 10. Overall performance: Mean RT for all 20 test pairs as a function of Self-Referencing and Position in Experiment 2.

Table 16

2 (Self-Referencing) X 5 (Position of Self-Referencing) ANOVA Table: Experiment 2

Dependent Variable: Mean RT from all 20 pairs

Independent Variables:

Between Factor (A) --- Self-Referencing

A_1 - Experimental Group
A_2 - Control Group

Within Factor (B) ---- Position of Self-Referencing

B_1 - Position 1
B_2 - Position 2
B_3 - Position 3
B_4 - Position 4
B_5 - Position 5

SOURCE	SS	DF	MS	F	P
between					
A	322621.11	1	783380.22	.11	.746
S(A)	176194389.3	58	3037834.3		
within					
B	4685670.67	4	1171417.6	4.88*	.001
AB	1813114.45	4	453278.61	1.89	.113
BS(A)	55678889.67	232	239995.21		
Pooled	231873278.97	290	799563.03	[S(A) & BS(A)]	
A at B_1	1022290.54	1	1022290.54	1.29[a]	
A at B_2	404507.10	1	404507.15	0.51	
A at B_3	599102.90	1	599102.90	0.75	
A at B_4	104366.84	1	104366.84	0.13	
A at B_5	5468.18	1	5468.18	0.01	
B at A_1	4777299.92	4	1194325.0	4.98*[b]	
B at A_2	1721485.08	4	430371.27	1.79	

Note. $^{a}F_{.15/7;\ 1,\ 97} = 6.5$
$^{b}F_{.15/7;\ 4,232} = 3$

16, there was a significant Position main effect, $F(4, 232) = 4.88$, $p < .001$. Self-Referencing, however, did not produce a significant main effect, $F(1, 58) = .11$, $p > .05$. The interaction between these two factors was also non-significant, $F(4, 232) = 1.89$, $p > .05$.

Since the present experiment was particularly concerned with the simple main effects of Self-Referencing and position, further analyses were conducted. As shown in Table 16, none of the Self-Referencing simple main effects were significant. However, for the Position factor, the simple main effect was found to be significant in the experimental group, $F(4, 232) = 4.98$, but not in the control group, $F(4, 232) = 1.79$.

Self-Reference vs. Other pair types. As described in the first experiment, it was possible to distinguish two types of pair comparisons in each task by identifying whether or not the pair comparison included a "You" term (See Table 17). However, due to the fact that different pairs were selected when "You" was placed at different positions, it was appropriate to examine only the Self-Referencing Effect but not the Position effect.

Table 18 gives means and standard deviations of RTs for the two types of pair comparisons in each experimental and control condition. Figure 11 is a plot of means for the Self-Reference Pair Type, whereas Figure 12 is a plot of means for the Other Pair Type. As shown in Figure 11, the

Table 17

Pairs with a You term (Marked with a X) as a Function of Position: Experiment 2

Test Pairs	Position				
	1(A)	2(B)	3(C)	4(D)	5(E)
A > B	X	X			
A > C	X		X		
A > D	X			X	
A > E	X				X
B > C		X	X		
B > D		X		X	
B > E		X			X
C > D			X	X	
C > E			X		X
D > E				X	X
E > D				X	X
E > C			X		X
E > B		X			X
E > A	X				X
D > C			X	X	
D > B		X		X	
D > A	X			X	
C > B		X	X		
C > A	X		X		
B > A	X	X			

Table 18

Means and Standard Deviations of RT (in Milliseconds) for Self-Reference Pairs and Other Pairs as a Function of Self-Referencing and Position: Experiment 2 (N=60)

Position		Condition		
		Experimental	Control	Total
1 (A)				
Self-Reference Pairs	M	2161.90	2775.15	2468.52
	SD	718.33	896.82	863.88
Other Pairs	M	3424.20	3428.26	3426.23
	SD	1060.79	1104.74	1073.77
2 (B)				
Self-Reference Pairs	M	2688.05	3272.12	2980.09
	SD	625.84	1225.88	1008.91
Other Pairs	M	3345.00	3223.72	3284.76
	SD	1018.07	1265.67	1140.43
3 (C)				
Self-Reference Pairs	M	3136.50	3279.28	3207.89
	SD	1109.57	1124.03	1109.65
Other Pairs	M	3559.94	3120.66	3340.30
	SD	1128.65	1090.69	1122.46
4 (D)				
Self-Reference Pairs	M	2779.52	3282.15	3030.83
	SD	667.74	851.36	799.79
Other Pairs	M	3188.50	2992.72	3090.61
	SD	803.51	941.25	873.25
5 (E)				
Self-Reference Pairs	M	2388.21	2774.93	2581.57
	SD	760.63	957.13	879.03
Other Pairs	M	3265.29	3035.59	3150.44
	SD	693.10	1006.54	864.59
Total				
Self-Reference Pairs	M	2630.84	3076.72	2853.78
	SD	610.71	833.58	758.56
Other Pairs	M	3356.59	3160.19	3258.39
	SD	816.80	902.25	858.99

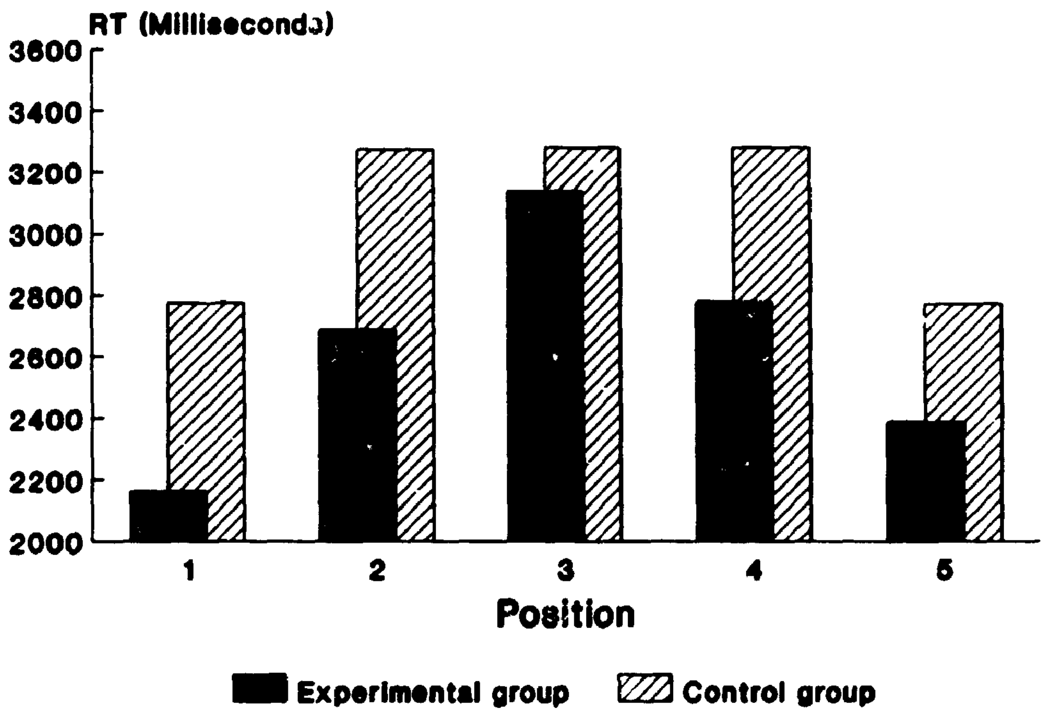


Figure 11. Mean RT for Self-Reference pairs as a function of Self-Referencing and Position in Experiment 2.

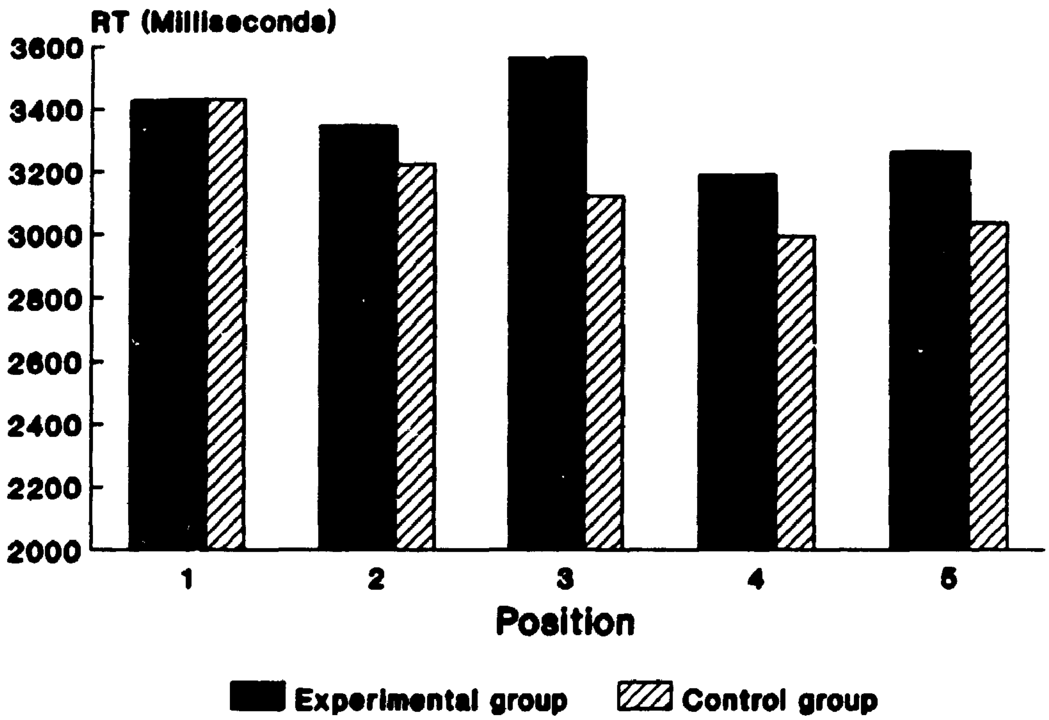


Figure 12. Mean RT for Other pairs as a function of Self-Referencing and Position in Experiment 2.

Self-Referencing group outperformed the Control group in every condition involving Self-Reference pairs. Regardless of where the "You" term was placed, the experimental group had a shorter RT on Self-Reference Pairs than the control group. On the other hand, as shown in Figure 12, the control group outperformed the experimental group for the Other pairs, where no "You" term was involved in the pair comparison. This was true for all levels of You position except for the condition where "You" was at the first position. When "You" was in the first position, the experimental group seemed to perform equally well as the control group.

Table 19 shows the results of a 2 (Self-Referencing) X 5 (Position of Self-Referencing) X 2 (Pair Type) ANOVA. As indicated in this table, Position of Self-Referencing had a significant main effect on RT, $F(4, 232) = 6.19$, $p < .001$, and the interaction of Position with Pair Type was also significant, $F(4, 232) = 14.81$, $p < .001$. The three way interaction, however, was non-significant, $F(4, 232) = .09$, $p > .05$. As shown in Table 19, further analyses of the simple main effects of Self-Referencing did not reveal any significance.

<u>Serial position and endpoint effects</u>. As in Experiment 1, RTs from true and false statement regarding adjacent pairs were averaged, and four serial positions were derived (A-B, B-C, C-D, D-E). If the endpoint effect was evident, a

Table 19

2 (Self-Referencing) X 5 (Position of Self-Referencing) X 2 (Pair Type) ANOVA Table: Experiment 2

Dependent Variable: Mean RT

Independent Variables:

Between Factor (A) --- Self-Referencing

A_1 - Experimental Group
A_2 - Control Group

Within Factor (B) ---- Position of Self-Referencing

B_1 - Position 1
B_2 - Position 2
B_3 - Position 3
B_4 - Position 4
B_5 - Position 5

Within Factor (C) ---- Pair Type

C_1 - Self-Reference Pairs
C_2 - Other Pairs

SOURCE	SS	DF	MS	F	P
between					
A	2334237.99	1	2334237.99	.40	.531
S(A)	340977312.6	58	5878919.2		
within					
B	12155559.43	4	3038889.9	6.19*	.000
AB	3680463.42	4	920115.86	1.87	.116
BS(A)	113973073.2	232	491263.25		
C	24556214.70	1	24556214.70	49.74*	.000
AC	15469744.93	1	15469744.93	31.43*	.000
CS(A)	28632474.74	58	493663.36		
BC	16078992.81	4	16078992.81	14.81*	.000
ABC	93897.64	4	93897.64	.09	.987
BCS(A)	62989772.16	232	271507.64		
Pooled	546572632.7	580	942366.61 (all 4 error terms)		
A at B_1C_1	5641188.19	1	5641188.19	5.99[a]	
A at B_2C_1	5116928.11	1	5116928.11	5.43	
A at B_3C_1	305799.07	1	305799.07	0.32	
A at B_4C_1	3789513.07	1	3789513.07	4.02	
A at B_5C_1	2243193.76	1	2243193.76	2.38	
A at B_1C_2	248.05	1	248.05	0.00	
A at B_2C_2	220638.98	1	220638.98	0.23	
A at B_3C_2	2894424.26	1	2894424.26	3.07	
A at B_4C_2	574995.58	1	574995.58	0.61	
A at B_5C_2	791417.93	1	791417.93	0.84	

Note. [a]$F_{.20/10;1,142} = 6.12$

serial position effect should be observed. Table 20 gives means and standard deviations of RT for the pairs in different serial positions.

Table 21 shows the results from a 2 (Self-Referencing) X 5 (Position of Self-Referencing) X 4 (Serial Position) ANOVA. There was a significant Serial Position effect, $F(3, 108) = 25.30$, $p < .001$, and a significant interaction between Serial Position and Self-Referencing Position, $F(12, 432) = 3.50$, $p < .001$. The three-way interaction was also significant, $F(12, 432) = 2.75$, $p < .001$.

Figure 13 is a plot of means for the control group, in which the five conditions were pooled. It may be noted that a classic endpoint effect was evident: the A-B and D-E pairs had the shortest RTs, following by B-C and C-D pairs.

Using the serial position curve from the control group as a comparison, the serial position curves for the five different "You" positions used with the experimental group, Position 1 (A), 2 (B), 3 (C), 4 (D) and 5 (E) are shown in Figures 14, 15, 16, 17 and 18 respectively. Similar to the results observed in the first experiment, serial position effects changed according to the position of the "You" term. As shown in Figure 14, when the "You" term was at the first position, the first endpoint (A) effect was stronger. When the "You" term was placed at the second (B) position (see Figure 15), the RT for A-B and B-C were shortest, followed by D-E and then C-D. These behaviour patterns were similar

Table 20

Means and Standard Deviations of RT (in milliseconds) for Adjacent Pairs as a Function of Self-Referencing and Position: Experiment 2

Position		Serial Position A-B	B-C	C-D	D-E
1 (A)					
Experimental[a]	*M*	2026.05	3487.14	3807.13	3604.26
	SD	963.85	1310.33	1690.71	1374.61
Control[b]	*M*	2724.48	3373.57	3875.24	3117.22
	SD	2724.48	3373.57	3875.24	3117.22
2 (B)					
Experimental	*M*	2028.80	2805.82	4027.12	3578.38
	SD	634.15	990.83	1495.49	1568.27
Control	*M*	2746.50	3711.81	3328.64	3569.67
	SD	1582.03	1763.77	1052.15	1706.20
3 (C)					
Experimental	*M*	3357.03	3197.68	3338.50	3919.60
	SD	1550.35	1451.52	1649.02	1592.63
Control	*M*	2670.86	3121.50	3714.41	3169.40
	SD	1484.63	1120.65	1637.75	1263.57
4 (D)					
Experimental	*M*	2924.86	3436.06	2918.68	2850.32
	SD	822.92	952.685	1084.00	1347.54
Control	*M*	2730.08	3402.00	3578.78	3306.61
	SD	1026.29	1554.35	1247.74	1641.46
5 (E)					
Experimental	*M*	3134.45	3232.36	[illegible]524.44	2631.15
	SD	1167.95	932.09	1159.70	1195.06
Control	*M*	2721.07	3412.15	3490.26	2780.35
	SD	1235.47	1713.88	1404.26	1119.83

Note: [a] *n* = 22
[b] *n* = 16

Table 21

2 (Self-Referencing) X 5 (Position of Self-Referencing) X 4 (Serial Position) ANOVA Table: Experiment 2

Dependent Variable: Mean RT

Independent Variables:

Between Factor (A) --- Self-Referencing

A_1 - Experimental Group
A_2 - Control Group

Within Factor (B) ---- Position of Self-Referencing

B_1 - Position 1
B_2 - Position 2
B_3 - Position 3
B_4 - Position 4
B_5 - Position 5

Within Factor (C) ---- Serial Position

C_1 - A-B
C_2 - B-C
C_3 - C-D
C_4 - D-E

SOURCE	SS	DF	MS	F	P
between					
A	5757809.55	1	5757809.55	.52	.477
S(A)	401406451.3	36	11150179		
within					
B	11954088.89	4	2988522.2	2.16	.077
AB	4069392.05	4	1017348.0	.73	.570
BS(A)	199352997.8	144	1384395.8		
C	91398450.48	3	30466150	25.30*	.000
AC	3303051.52	3	1101017.2	.91	.437
CS(A)	130030541.9	108	1203986.5		
BC	48104248.84	12	4008687.4	3.50*	.000
ABC	37803949.33	12	3150329.1	2.75*	.001
BCS(A)	495039815.9	432	1145925.5		

whereas an additional .01 % of data should have been eliminated if the lower bound on acceptable RT's had been raised to 250 milliseconds.

Overall performance. The average RT from the 20 test pairs represented the overall performance for each subject. Table 26 shows the means and standard deviations of overall performance for all conditions. Figure 21 is a plot of these means. As shown in this figure, the performance trend over the five different positions for the experimental condition was very similar to that found in the two previous experiments. When "You" was placed at the first and fifth position, subjects performed the best, followed by the condition where "You" was at the second and fourth position. When a "You" term was placed at the third position, performance was the worst.

As shown in Table 27, a 5 (Self-Referencing Position) X 2 (Self-Referencing) ANOVA revealed no significant main effects or interactions. However, further analysis of simple main effects showed that for the experimental condition, the Position effect did approach statistical significance, $F(4, 162) = 2.11$, $p > .05$.

Self-Reference vs. Other pair types. As in the previous experiments, the 20 pairs presented after each paragraph were classified into two types: Self-Reference Pairs and Other pairs. Table 28 gives their means and standard deviations.

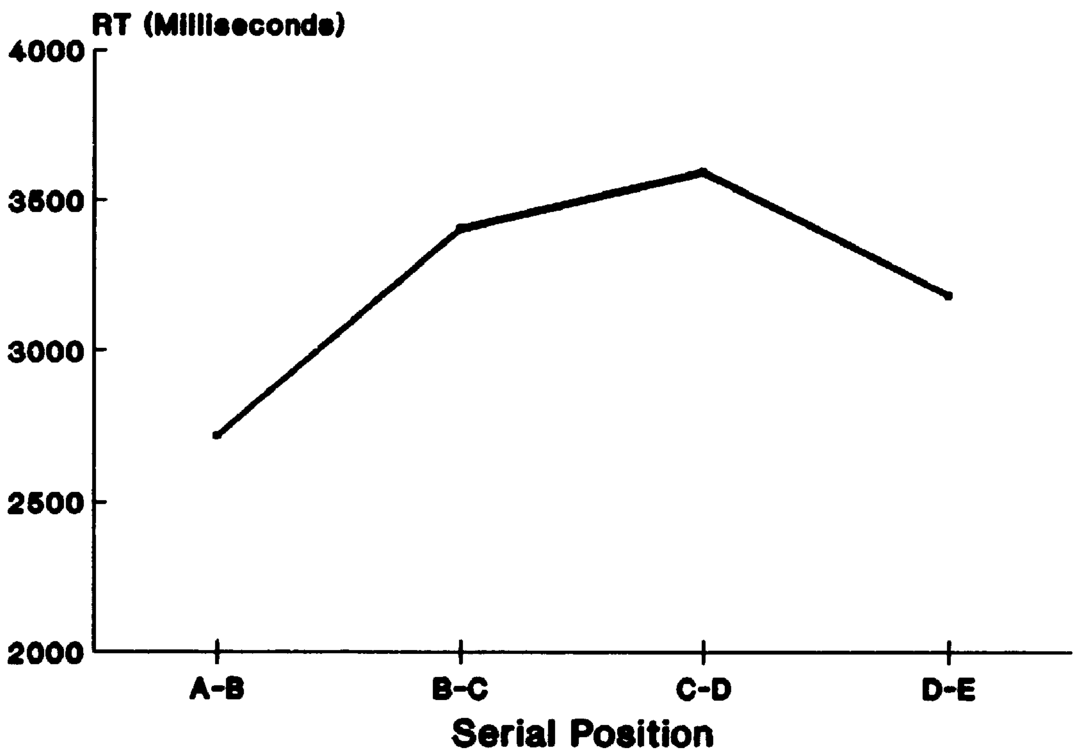


Figure 13. Serial position effect for the Control group: Mean RT for adjacent pairs as a function of serial position in Experiment 2.

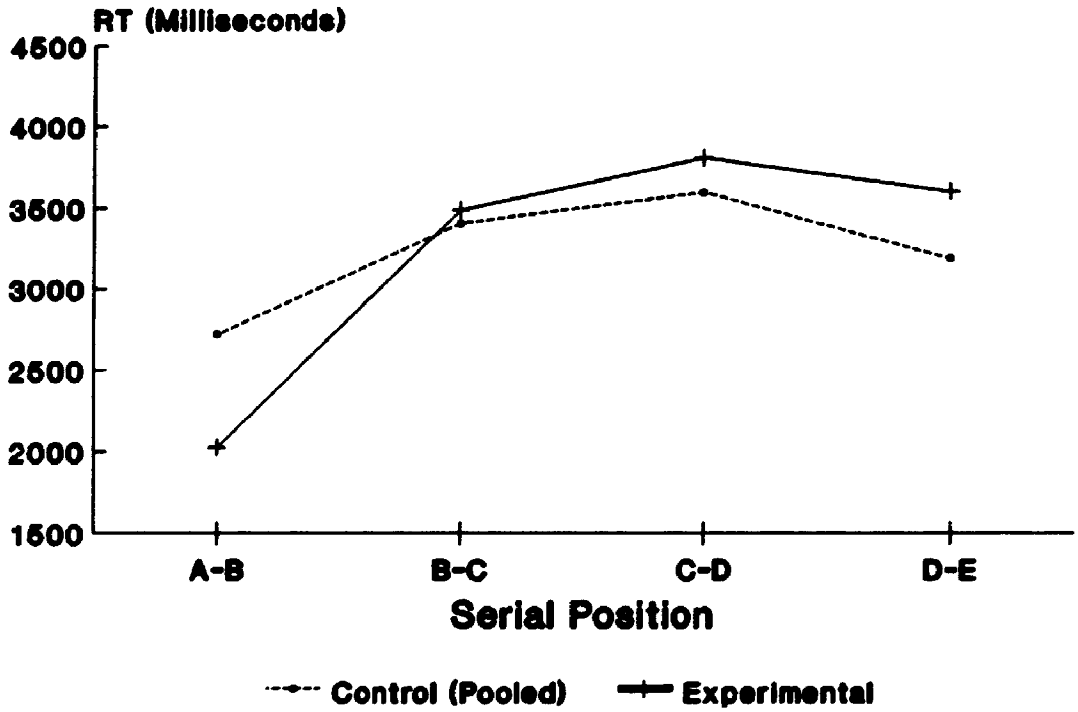


Figure 14. Serial position effect for the Experimental group with "You" term in Position 1 (A): Mean RT for adjacent pairs as a function of serial position in Experiment 2.

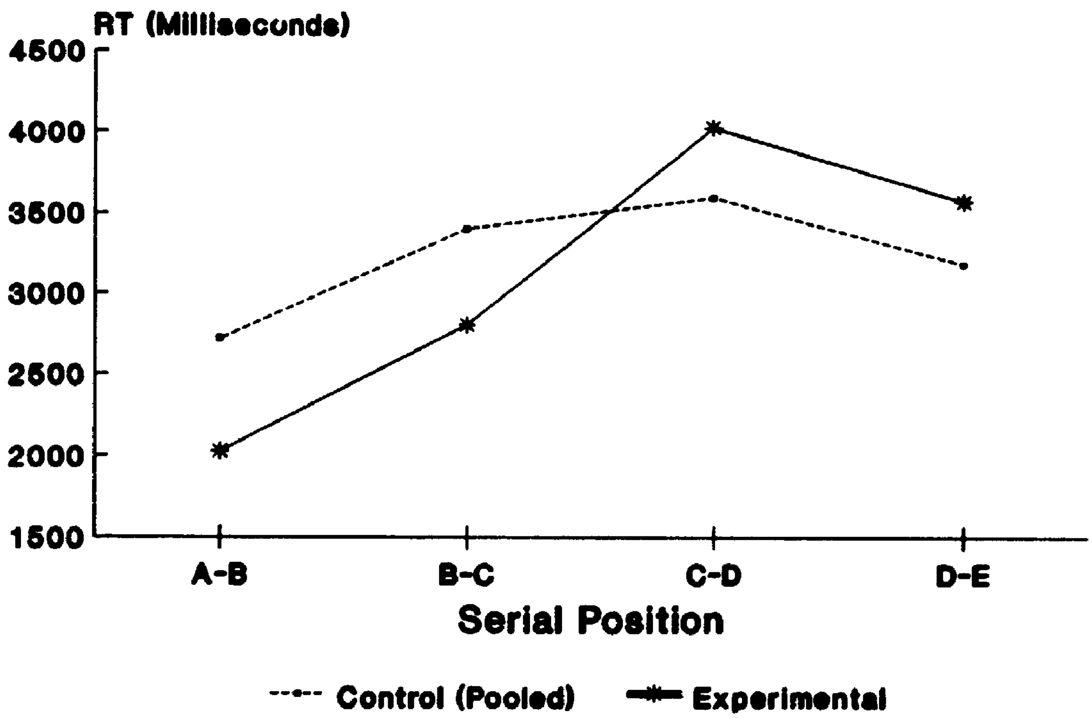


Figure 15. Serial position effect for the Experimental group with "You" term in Position 2 (B): Mean RT for adjacent pairs as a function of serial position in Experiment 2.

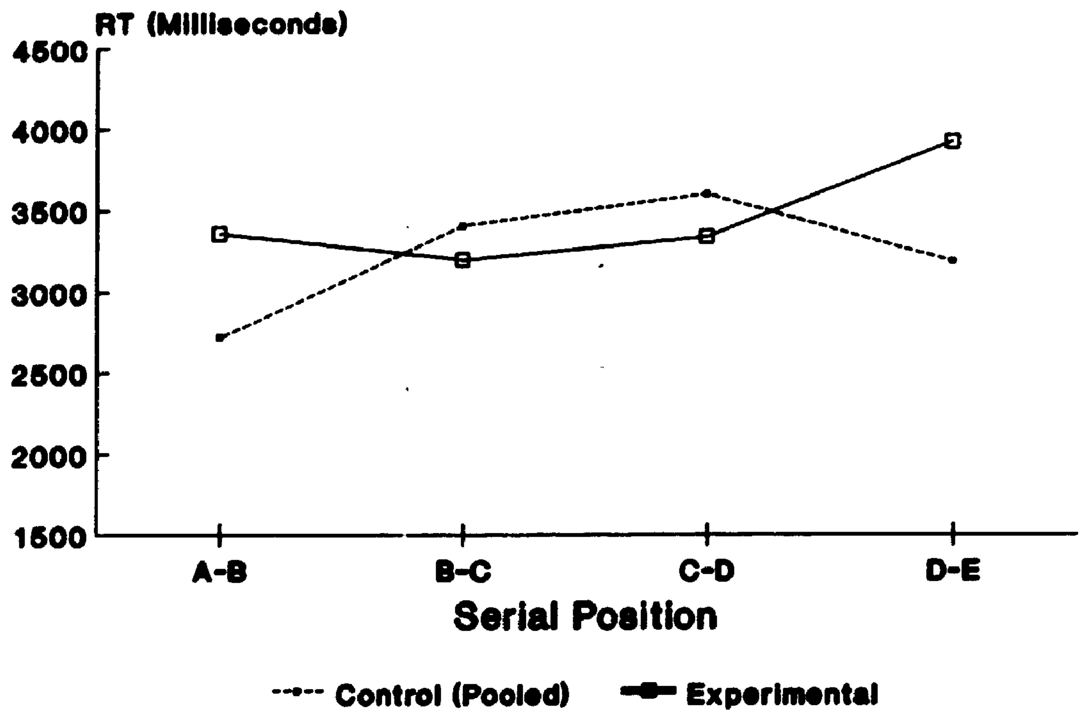


Figure 16. Serial position effect for the Experimental group with "You" term in Position 3 (C): Mean RT for adjacent pairs as a function of serial position in Experiment 2.

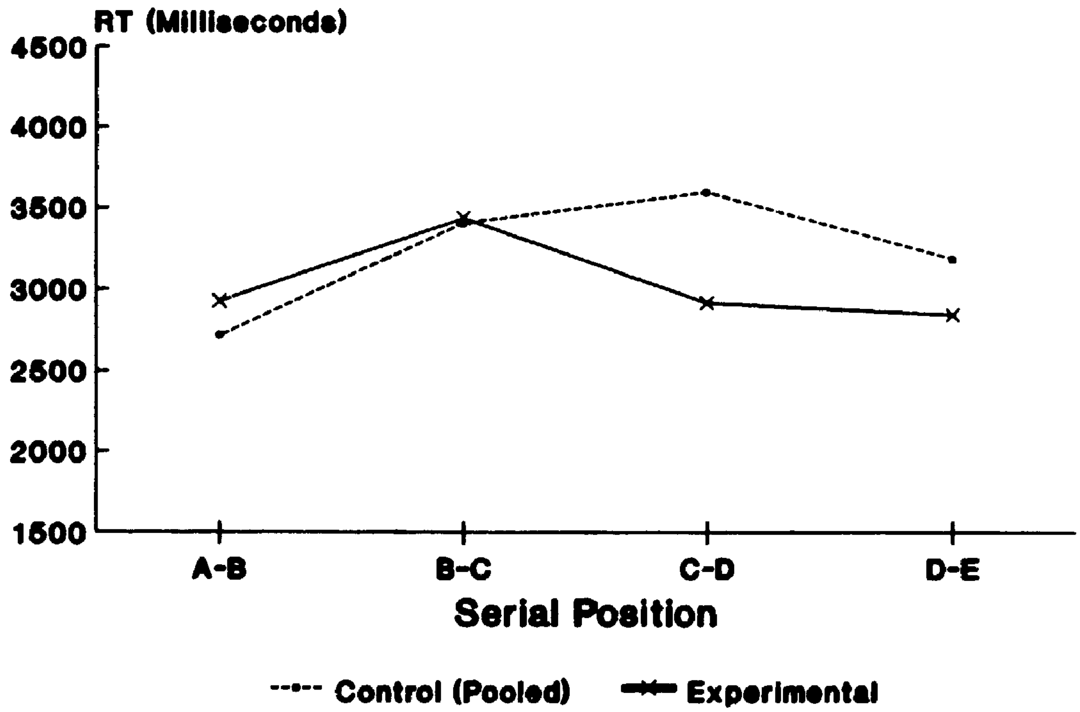


Figure 17. Serial position effect for the Experimental group with "You" term in position 4 (D): Mean RT for adjacent pairs as a function of serial position in Experiment 2.

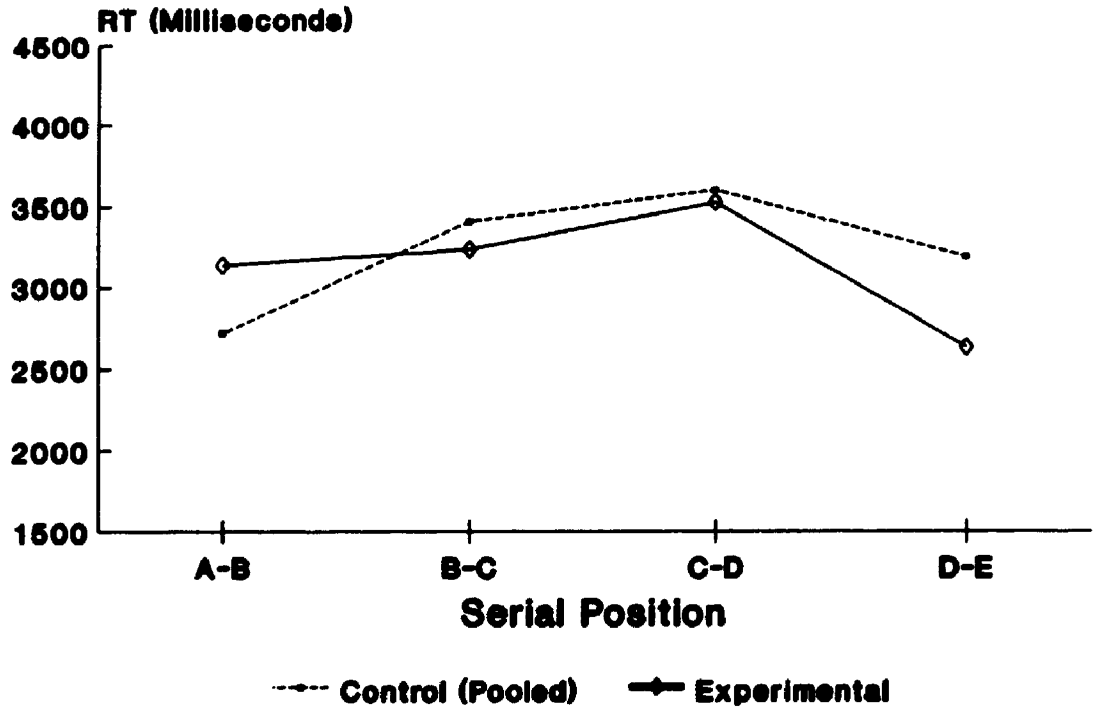


Figure 18. Serial position effect for the Experimental group with "You" term in Position 5 (E): Mean RT for adjacent pairs as a function of serial position in Experiment 2.

for the conditions where "You" was at fifth (E), and fourth (D) positions (See Figure 18, and 17 respectively). A dramatic difference was found, however, when the "You" term was placed at the third (C) position. As shown in Figure 16, the endpoint effect disappeared under this condition, and the shortest RTs were found at B-C and C-D pairs, whereas A-B and D-E had the longest RTs.

Distance effect. The distance effect was tested by excluding pairs with one or more endpoints. The 6 inner pairs were classified to be either 1-step or 2-step. Table 22 shows means and standard deviations of RT on these two types of pairs. For the control group, as shown in Figure 19, the 2-step pairs all had slightly shorter RT than the 1-step pairs except for the third position trials. For the experimental group, the 2-step pairs had slightly shorter RT than the 1-step pairs at Positions 2, 4 and 5. However, at Positions 1 and 3, the direction was reversed (See Figure 20).

A 2 (Self-Referencing) X 5 (Position of Self-Referencing) X 2 (Distance) ANOVA showed a non-significant distance main effect, $F(1, 49) = .03$, $p > .05$. No two-way or three-way interaction were significant either (See Table 23).

Self-report data on strategy use and self referencing. Following each testing session of the experiment, subjects were asked to type in the ordering of the names that they

Table 22

Means and Standard Deviations of RT (in milliseconds) for 1-step and 2-step Inner Pairs as a Function of Self-Referencing and Position: Experiment 2

Position		Condition		
		Experimental *n* = 26	Control *n* = 25	Total *N* = 51
1 (A)				
1-step pairs	*M*	3623.45	3614.23	3618.93
	SD	1314.29	1184.16	1239.67
2-step pairs	*M*	3643.60	3587.48	3616.09
	SD	1664.96	1486.69	1564.53
2 (B)				
1-step pairs	*M*	3391.94	3462.41	3426.49
	SD	869.51	1072.97	965.35
2-step pairs	*M*	3095.67	3440.06	3264.49
	SD	1069.67	1440.57	1264.29
3 (C)				
1-step pairs	*M*	3215.23	3289.78	3251.77
	SD	1355.56	1067.75	1211.38
2-step pairs	*M*	3530.37	3736.20	3631.27
	SD	1303.92	1308.17	1297.05
4 (D)				
1-step pairs	*M*	3145.84	3393.94	3267.46
	SD	882.67	1053.42	968.45
2-step pairs	*M*	2817.17	3189.68	2999.78
	SD	869.51	982.54	936.36
5 (E)				
1-step pairs	*M*	3435.69	3343.03	3390.27
	SD	886.40	1299.82	1098.19
2-step pairs	*M*	3388.85	3334.94	3362.42
	SD	1184.82	1537.09	1355.25

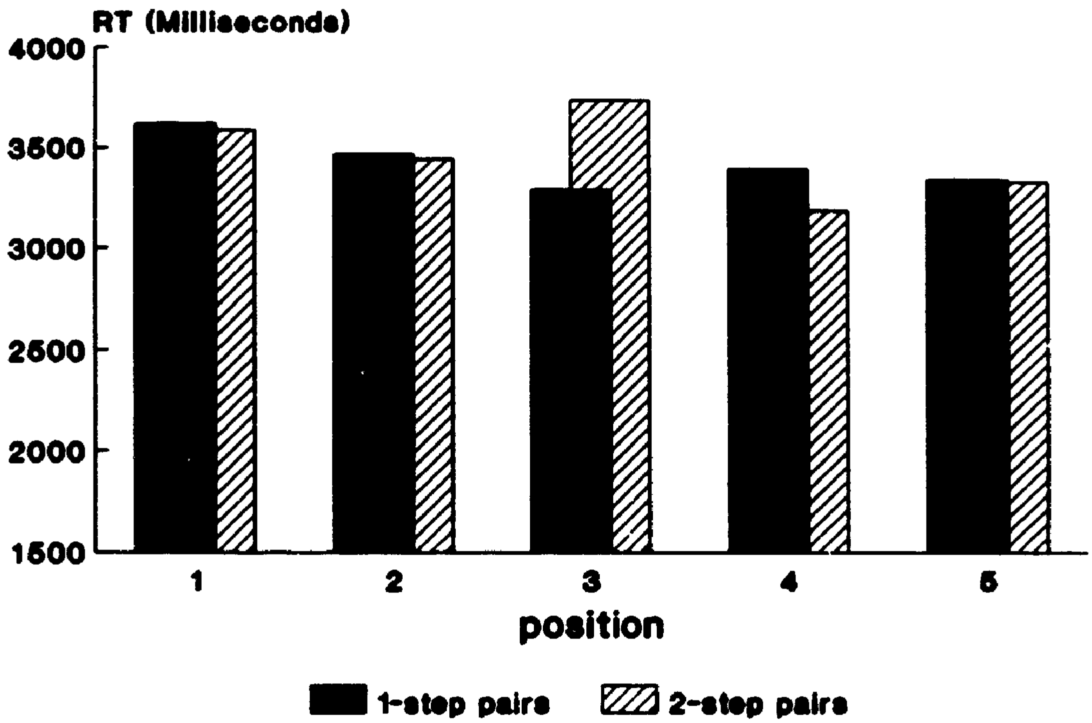


Figure 19. Distance effect for the Control group: Mean RT for 1-step and 2-step pairs as a function of Position in Experiment 2.

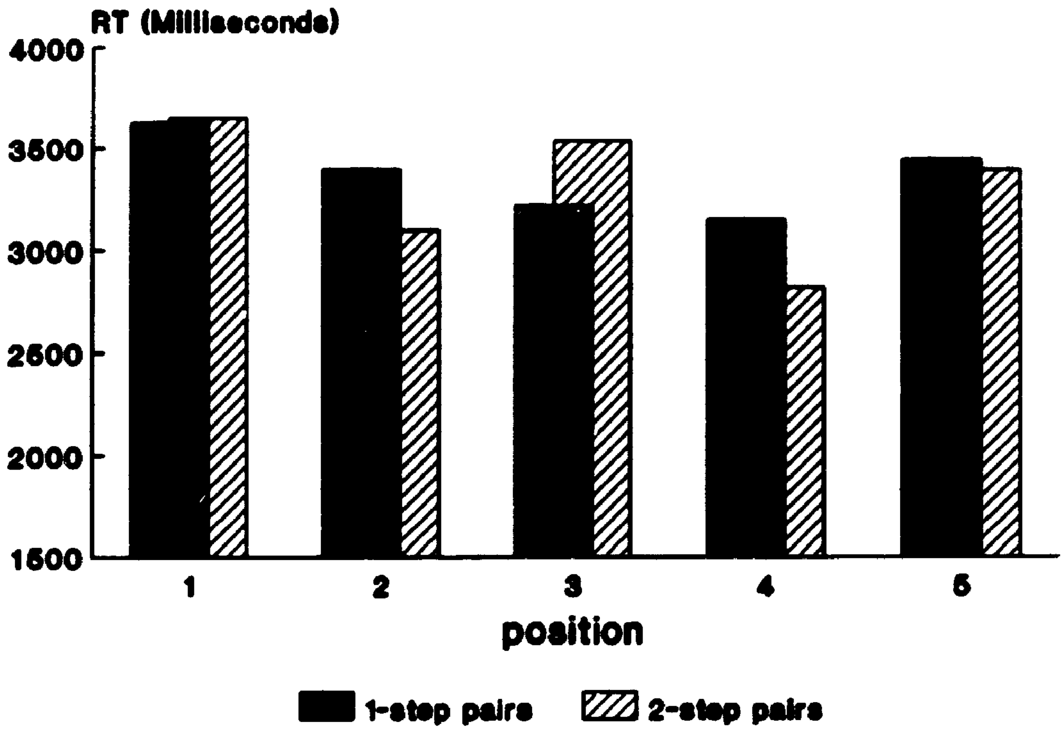


Figure 20. Distance effect for the Experimental group: Mean RT for 1-step and 2-step pairs as a function of Position in Experiment 2.

Table 23

2 (Self-Referencing) X 5 (Position of Self-Referencing) X 2 (Distance) ANOVA Table: Experiment 2

Dependent Variable: Mean RT

Independent Variables:

Between Factor (A) --- Self-Referencing

A_1 - Experimental Group
A_2 - Control Group

Within Factor (B) ---- Position of Self-Referencing

B_1 - Position 1
B_2 - Position 2
B_3 - Position 3
B_4 - Position 4
B_5 - Position 5

Within Factor (C) --- Distance

C_1 - 1-Step Pairs
C_2 - 2-Step Pairs

SOURCE	SS	DF	MS	F	P
between					
A	1553248.27	1	1553248.27	.26	.612
S(A)	291248385.2	49	5943844.6		
within					
B	12278525.58	4	3069631.4	2.46*	.047
AB	2663049.67	4	665762.42	1.76	.712
BS(A)	244817058.5	196	1249066.6		
C	29259.45	1	29259.45	.03	.824
AC	346570.33	3	346570.33	.41	.527
CS(A)	41792168.08	49	852901.39		
BC	6142982.51	4	1535745.6	2.10	.082
ABC	363597.71	4	90899.43	.12	.974
BCS(A)	143317184.6	196	731210.13		

used in answering the questions. Questions on strategy use and self referencing were also presented after the tasks. Of the 60 subjects, 36.7% reported that they did not use any strategies other than repetition. The most common reported strategy other than repetition was to use the first letter of each name to simplify the task. For example, instead of saying Tom-John-Rod-Paul-Bob, subjects recorded it as T-J-R-P-B. Approximately 45% of subjects reported that they used this strategy to help remember the ordering. Two subjects described how they deliberately isolated the ends first by identifying people who were at the two ends.

In terms of between-groups comparison, subjects did not differ appreciably in their strategy use. Ten out of 30 subjects from the experimental group reported that they did not use any strategy, whereas 12 of 30 control subjects reported no strategy use. For the experimental group, 12 subjects said they used a first letter strategy, whereas 16 control subjects responded in this way.

Subjects in the experimental group were asked to report whether they referred the "You" term to themselves, or just treated it as another name. Twenty nine out of 30 subjects answered the question in a clear fashion: 19 said they referred the "You" term to themselves, whereas 10 said they did not. Some subjects reported that though they treated the "You" term as just another name, it was nonetheless easier to remember.

An interesting observation was that when asked to type in the sequence of names that was used to answer test questions, 11 subjects in the experimental group used "Me" or their own name to replace the "You" term. Two subjects even omitted the "You" term completely, as if it did not take special effort to memorize its position.

Discussion

In general, the findings of Experiment 2 are highly consistent with the results in Experiment 1. The expectation that Self-Referencing would motivate subjects and improve overall performance was again not supported. The Position main effect on overall performance, however, was significant. Since the "You" position effect was significant in Experiment 1 for the experimental group and not for the control group, further analyses were done to test this observation. The findings of these analyses were in accordance with the first experiment. For the control group, as anticipated, the Position variable did not have a significant effect. For the experimental group, however, the Position effect was significant. Performance level showed an inverted V trend when the "You" term was placed at each position of the 5-term linear ordering from first to last. Position 1 and Position 5 conditions provided the best performance, whereas Position 3 resulted in the worst performance. When "You" was at Position 2 and Position 4, overall performance was intermediate.

Moreover, when Pair Type was included as a factor in the analysis, it had a significant interaction with Self-Referencing. This interaction implied that though Self-Referencing did not result in better overall performance, it did change the way subjects stored and processed information. For Self-Reference Pairs, the experimental group performed better than the control group at all five positions. For Other Pairs, the direction was reversed in all positions except for position 1, where the control and experimental groups had similar levels of performance. These behavioral patterns were exactly the same in Experiment 1 and in Experiment 2.

Although behavioral patterns were highly consistent in the two experiments, these patterns did not lead to significant results in the statistical testing of simple main effects. This observation casts serious doubt on the power of the tests. It may be noted that although the number of subjects in the second experiment was increased to 30 per cell, the error terms in these analyses appeared to be much greater compared to those in Experiment 1. The inflation of error terms in the present experiment may be mainly due to the decreased number of trials. In Experiment 1, subjects were tested twice on the same 20 questions for each task. In Experiment 2, however, in order to avoid extreme fatigue, subjects were tested on the 20 questions once only. Thus, despite the effort of increasing the number of subjects in the present experiment, there may still be inadequate power for the tests.

The findings on serial position effects in the present experiment are also very similar to those found in Experiment 1. For the two conditions added, Position 2 and Position 4, RT for the pairs relating to the position where the "You" term was placed also appeared to be the shortest. These observations reinforce the theory that people use "You" as a focus in organizing information.

As in Experiment 1, the present experiment did not reveal a significant distance effect. Though this finding fails to support the hypothesis based on Pott's findings (1974), it is consistent with the results from the first experiment. For both experimental and control groups, 2-step pairs did not have a shorter RT than the 1-step pairs.

Descriptive self-report data were obtained from subjects in the present study. These data provide some information on the types of strategies people use when confronting a linear ordering task. Of the 29 subjects who gave clear indication in their responses, 66% indicated that they referred the "You" term to themselves, whereas the other 34% indicated that they did not refer the "You" term to themselves. Further exploratory analyses were done to examine whether this factor (Reported Self-Referencing) made a difference in subjects' performance. For the 29 experimental subjects only, a 5 (Position) X 2 (Reported

Self-Referencing) ANOVA was performed on RT data. It was found that the performance of those subjects who referred the "You" term to themselves ($\underline{M}$ = 3105.38) was not significantly different from that of subjects who did not refer the "You" term to themselves ($\underline{M}$ = 2931.30), $\underline{F}$ (1,27) = .39, $\underline{p}$ > .05. Furthermore, Reported Self-Referencing had no significant interaction with Position, $\underline{F}$(4, 108) = .57, $\underline{p}$ > .05. Therefore, whether or not subjects referred the "You" term to themselves did not seem to make a significant difference in their performance or behaviour pattern. Two possible explanations for this phenomenon are postulated. One is that the subjects may not be fully aware of their own cognitive processes. Therefore, though they claimed they did not refer the "You" term to themselves, self-referencing did in fact occur. Alternatively, it is possible that for subjects who did not refer the "You" term as themselves, the word "You" was perceptually distinctive enough that subjects used it effectively as a focus in organizing information. From an educational point of view, however, the results in the present experiment clearly indicate that using the word "You" in a task is sufficient to direct students' attention and to change cognitive processing.

It is interesting to note that the most commonly used strategy was to code the first letter of the names. In Experiment 1 and Experiment 2, Ann was used to replace the "You" term for the female subjects in the control group.

Since many subjects use first-letters acronyms to help remembering the sequence of the names, placing a name starting with a vowel, like Ann, at different positions may result in some unexpected differential effects. For example, having a vowel in position 2, 3, and 4 may be easier for the subjects to make up a word with the five letters than placing the vowel in the two ends. In Experiment 3 special attention was taken to prevent this possible bias.

In short, the present experiment replicated most of the findings from Experiment 1. Though the overall performance on the task was not affected by self-referencing, the cognitive effect was evident. The results indicate that people use the "You" term as a focus in organizing information. Moreover, the effects of the various "You" positions implies that of the five positions in a 5-term linear ordering, endpoint anchoring is most effective for organizing information, and that the further away the focus is from the endpoints, the worse the performance becomes.

Experiment 3

The main goal of Experiment 3 was to replicate the findings of the previous two experiments, and to provide greater power for statistical testing of the effect of Self-Referencing. As described earlier, though very similar patterns of findings were observed for the Self-Referencing effect in Experiments 1 and 2, the statistical analyses did not seem to have sufficient power to detect this effect. Since the Self-Referencing Effect is the major factor in this research, it is important to provide an adequate test of this effect.

In Experiment 2, an attempt to increase the power of statistical tests by increasing the number of subjects was unsuccessful with respect to obtaining a self-referencing effect. As discussed earlier, this problem may have stemmed from the decreasing number of trials in the tasks. Nonetheless, it does not seem appropriate to increase the number of trials with a design like the one used in Experiment 2. Subjects would have to go through 5 different linear ordering relations and answer 200 test questions if the 20 test pairs were presented twice each for all five tasks. This excessive testing is considered too demanding for the subjects and may result in extreme fatigue or boredom.

Therefore, a different design was used in Experiment 3. In the previous two experiments, Self-Referencing was manipulated between subjects and Position of Self-Referencing was a within-subjects factor. Therefore, tests of the Self-Referencing effect were relatively less powerful than tests of the Position of Self-Referencing effect. In the present experiment, Self-Referencing was a within-subjects factor, whereas Position of Self-Referencing was a between-subjects factor. Thus, by changing the research design, the present study achieved greater statistical power for testing the effects of Self-Referencing.

In Experiment 3, subjects were randomly assigned to 5 different groups receiving different positions of self referencing: Position 1, Position 2, Position 3, Position 4, and Position 5. These five groups each had the "You" term placed at different positions in the linear ordering. All subjects went through two tasks, with one including a "You" term (Experimental Condition), and one without (Control Condition). As in the previous two experiments, the main dependent variable was RT to test questions, but error rates and encoding times were also recorded. As in Experiment 2, interview questions were presented to subjects after the task to collect descriptive self-report data on subjects' cognitive processing. Since subjects in the present experiment encountered both types of tasks, with and without a "You" term involved, it was believed that they might be better able to describe the effect of Self-Referencing in their cognitive processing.

Method

Subjects. One hundred and twenty university students (54 males and 66 females) from the Psychology 20 subject pool participated in this study. Subjects' mean age was 19.62 years (SD = 3.39). They were randomly assigned to the five Position groups with 24 subjects in each group. For Position 1 and Position 2 groups, 12 male and 12 female subjects were assigned, whereas for Positions 3, 4, and 5, there were 10 male and 14 female subjects per group.

Apparatus. A computer program was designed to present the learning materials and the test stimuli. Subjects were tested on a PS/2 Model 25 computer. The computer program incorporated the timing program designed by Graves and Bradley (1988) which provided millisecond timing.

Materials The learning materials were very similar to those used in previous experiments. Two sets of common one-syllable first names were used as different terms in the two paragraphs. Female names were used for the female subjects, while male names were applied to the male subjects. All the names started with different consonants. Any names that were identical to that of the subject were replaced by another one-syllable common name.

The following is an example of experimental and control sets of linear ordering presented to female subjects under the Position 1 condition:

> In one class, students are voting for a representative. There are 5 candidates. Among these 5 individuals, You are older than Rose, Rose is older than Joy, Joy is older than Pam, Pam is older than Bath.
>
> In another class, students are also voting for a representative. There are 5 candidates. Among these 5 individuals. Chris is older than Lynn. Lynn is older than Deb. Deb is older than Sue. Sue is older than Gail.

For male subjects, the two sets of names included in these paragraphs were Paul-Mark-Bob-Nick-Dan, and John-Ray-Tom-Chris-Ken. The presentation sequence of the two paragraphs remained the same for all subjects. The order of presenting the "You" term and the two sets of names in the first or second paragraphs, however, was completely counterbalanced. The two names "Chris" and "Kate" ("Paul" and "John" for the males), were used to replace the "You" term when it was not included in the ordering. The sequence of names was kept constant with the "You" term being inserted in the desired position for different groups. If the subject had a name that was identical to any of those given in the paragraph, "Mag" or "Steve" were used as a replacement.

Twenty statements about pair-wise relations were constructed for each linear ordering. The 20 questions were tested twice each after a study session. The presentation sequence of every 20 questions was randomized.

The following practice paragraph was constructed, along with a set of 12 test sentences, to familiarize subjects with the task:

> In a Green forest, the animals are voting for their leader. The hawk gets more votes than the frog. The frog gets more votes than the tiger. The tiger gets more votes than the rabbit.

Three post-experimental questions were constructed to obtain feedback from subjects about their cognitive processing. The first question was: "Did you use any special strategies to memorize the ordering of the names?" The second question was: "Did you refer the "You" term to yourself or just treat it as another name? For example, did you replace the word "You" with I, Me, myself, or your own name?". Finally the subjects were asked: "Did the "You" term in any way affect the way you memorized the names?"

Procedure. The procedures for this experiment were identical to those of the previous two experiments except there were only 2 study-test sessions in this experiment. The 20 test pairs for each linear ordering were tested twice. As in the second experiment, subjects were asked after each testing session to list the names according to the ordering they used when answering the questions.

Fifteen simple arithmetic questions were presented to subjects between tasks to decrease interference from the previous task. After subjects completed both tasks, they were asked to give self-report feedback about their cognitive processing. Questions were presented on the computer screen and the answers were typed in by subjects using the keyboard.

<u>Results</u>

The means and standard deviations of the reading time variable are shown in Table 24. A 5 (Position of Self-Referencing) X 2 (Self-Referencing) ANOVA revealed no significant main effect for either factor, $F(4, 115) = .39$, $p > .05$, and $F(1, 115) = 1.35$, $p > .05$ respectively. The interaction between these two factors was also not significant, $F(4, 115) = .67$, $p > .05$.

After each reading session, 40 test questions (20 questions twice each) were presented to the subjects. Table 25 shows the means and standard deviations of the error rates. As in the first two experiments, the mean error rates were uniformly low, ranging from .060 to .084. A 5 (Position of Self-Referencing) X 2 (Self-Referencing) ANOVA was applied to analyze these data. It was found that neither Position nor Self-Referencing had a significant main effect on error rate, $F(4, 115) = .16$, $p > .05$ and $F(1, 115) = .58$, $p > .05$, respectively. The interaction between these two factors was also non-significant, $F(4, 115) = .38$, $p > .05$.

Since the error rates were low, it was appropriate to analyze the RT data. The following analyses all used RT as the dependent variable. The RTs for the 20 pairs were calculated using the same steps applied in the first experiment. Approximately 0.9% of RT data were excluded from the analysis due to unusually high or low RTs,

Table 24

Means and Standard Deviations of Reading Time (in Seconds) as a Function of Self-Referencing and Position: Experiment 3 (N = 120)

		Condition	
Position		Experimental	Control
1 (A)	*M*	33.40	35.22
	SD	11.89	14.26
2 (B)	*M*	34.33	37.29
	SD	14.28	18.18
3 (C)	*M*	33.69	37.92
	SD	20.16	20.91
4 (D)	*M*	31.40	31.61
	SD	12.32	12.09
5 (E)	*M*	36.40	34.61
	SD	15.64	17.09
Total	*M*	33.85	35.33
	SD	14.98	16.65

Table 25

Means and Standard Deviations of Error Rates as a Function of Self-Referencing and Position: Experiment 3 (N = 120)

		Condition	
Position		Experimental	Control
1 (A)	M	.062	.060
	SD	.087	.079
2 (B)	M	.062	.084
	SD	.067	.072
3 (C)	M	.075	.071
	SD	.091	.081
4 (D)	M	.069	.076
	SD	.088	.077
5 (E)	M	.071	.075
	SD	.050	.079
Total	M	.068	.073
	SD	.077	.077

whereas an additional .01 % of data should have been eliminated if the lower bound on acceptable RT's had been raised to 250 milliseconds.

Overall performance. The average RT from the 20 test pairs represented the overall performance for each subject. Table 26 shows the means and standard deviations of overall performance for all conditions. Figure 21 is a plot of these means. As shown in this figure, the performance trend over the five different positions for the experimental condition was very similar to that found in the two previous experiments. When "You" was placed at the first and fifth position, subjects performed the best, followed by the condition where "You" was at the second and fourth position. When a "You" term was placed at the third position, performance was the worst.

As shown in Table 27, a 5 (Self-Referencing Position) X 2 (Self-Referencing) ANOVA revealed no significant main effects or interactions. However, further analysis of simple main effects showed that for the experimental condition, the Position effect did approach statistical significance, $F(4, 162) = 2.11$, $p > .05$.

Self-Reference vs. Other pair types. As in the previous experiments, the 20 pairs presented after each paragraph were classified into two types: Self-Reference Pairs and Other pairs. Table 28 gives their means and standard deviations.

Table 26

Means and Standard Deviations of RT (in milliseconds) for All 20 questions as a Function of Self-Referencing and Position: Experiment 3 (N = 120)

		Condition	
Position		Experimental	Control
1 (A)	*M*	2358.12	2416.34
	SD	710.90	622.04
2 (B)	*M*	2580.11	2558.19
	SD	798.45	628.97
3 (C)	*M*	2892.29	2689.83
	SD	936.38	590.18
4 (D)	*M*	2546.58	2715.28
	SD	594.36	513.30
5 (E)	*M*	2455.29	2515.38
	SD	416.06	611.19
Total	*M*	2571.88	2579.00
	SD	723.00	595.11

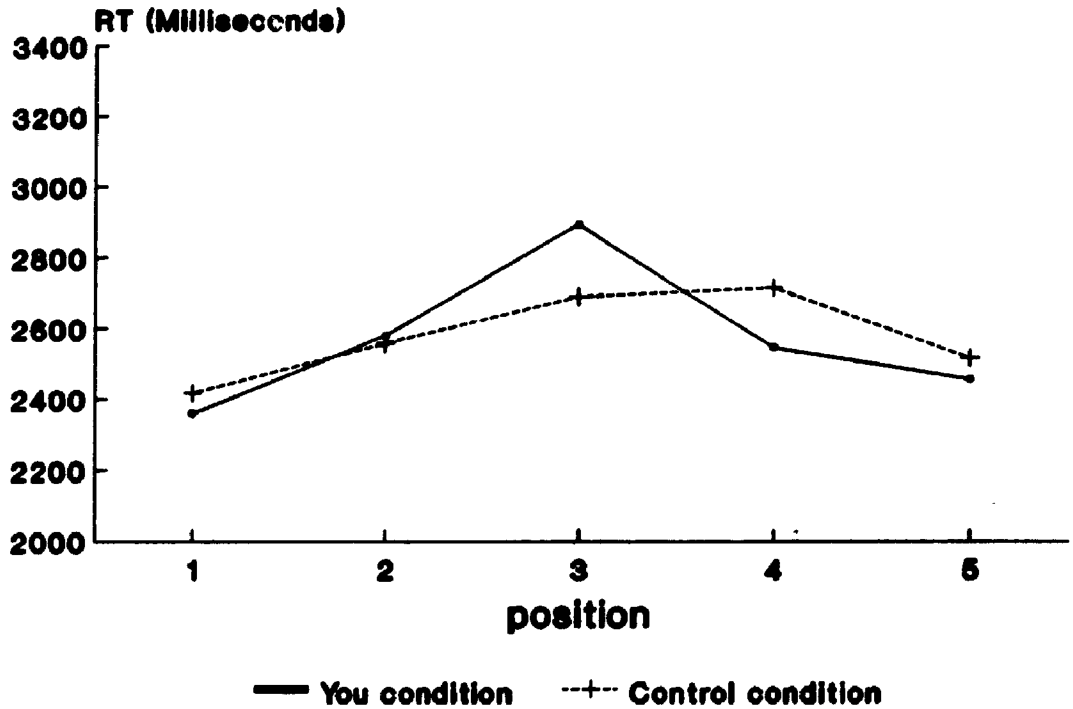


Figure 21. Overall performance: Mean RT for all 20 test pairs as a function of Self-Referencing and Position in Experiment 3.

Table 27

5 (Position of Self-Referencing) X 2 (Self-Referencing) ANOVA Table: Experiment 3

Dependent Variable: Mean RT from all 20 pairs

Independent Variables:

Between Factor (A) -- Position of Self-Referencing

A_1 - Position 1
A_2 - Position 2
A_3 - Position 3
A_4 - Position 4
A_5 - Position 5

Within Factor (B) --- Self-Referencing

B_1 - Experimental Condition
B_2 - Control Condition

SOURCE	SS	DF	MS	F	P
between					
A	4236105.81	4	1059026.5	1.49	.210
S(A)	81782394.74	115	711151.26		
within					
B	3043.91	1	3043.91	.02	.888
AB	891112.61	4	222778.15	1.47	.216
BS(A)	17439049.73	115	151643.91		
Pooled	99221444.47	230	431397.58	[S(A) & BS(A)]	
A at B_1	3644151.97	4	911037.99	2.11[a]	
A at B_2	1483066.44	4	370766.61	.86	

Note. $^aF_{.10/2;4,162} = 2.43$

Table 28

Means and Standard Deviations of RT (in Milliseconds) for Self-Reference Pairs and Other Pairs as a Function of Self-Referencing and Position: Experiment 3 (N = 120)

Position		Condition: Experimental	Condition: Control
1 (A)			
Self-Reference Pairs	*M*	1753.22	2211.15
	SD	523.14	691.12
Other Pairs	*M*	2813.84	2566.78
	SD	937.26	671.59
2 (B)			
Self-Reference Pairs	*M*	2193.34	2576.24
	SD	670.60	741.28
Other pairs	*M*	2843.67	2547.19
	SD	938.51	639.58
3 (C)			
Self-Reference Pairs	*M*	2822.78	2936.75
	SD	1147.15	672.30
Other pairs	*M*	2934.02	2526.16
	SD	869.94	651.94
4 (D)			
Self-Reference Pairs	*M*	2272.75	2828.05
	SD	603.38	678.41
Other pairs	*M*	2737.07	2639.94
	SD	675.69	533.50
5 (E)			
Self-Reference Pairs	*M*	1955.05	2369.78
	SD	571.46	835.55
Other pairs	*M*	2803.00	2593.97
	SD	455.90	575.23
Total			
Self-Reference Pairs	*M*	2199.43	2584.40
	SD	811.97	764.32
Other pairs	*M*	2826.50	2574.81
	SD	786.65	607.39

Since the pairs included in each Pair Type were different across the 5 levels of Position, the following analyses focused only on the effects of Self-Referencing and Pair Type. Figure 22 is a plot of mean RTs from Self-Reference pairs, whereas Figure 23 is a plot of mean RTs from Other pairs. It may be noted that, for all five groups, RT for Self-Reference pairs were faster in the "You" condition than in the control condition. On the contrary, RT for the Other pairs were uniformly faster in the control condition than in the experimental condition.

As shown in Table 29, a 5 (Position of Self-Referencing) X 2 (Self-Referencing) X 2 (Pair type) ANOVA revealed a significant Pair Type main effect, $F(1, 115) = 70.68$, $p < .001$. The two way interaction between Pair Type and Self-Referencing was also significant, $F(1, 115) = 54.90$, $p < .001$. The three way interaction, however, was not significant, $F(4, 115) = .14$, $p > .05$.

Further analysis of the simple main effects of Self-Referencing were significant both for Self-Reference pairs and for Other pairs, $F(1, 223) = 33.31$ and $F(1, 223) = 14.24$ respectively. In other words, when there was a "You" term involved in the task, subjects responded significantly faster on the Self-Reference pairs and significantly slower on the Other pairs, relatively to the control condition.

Serial position and endpoint effects. For the adjacent test pairs, RTs from true and false questions were averaged.

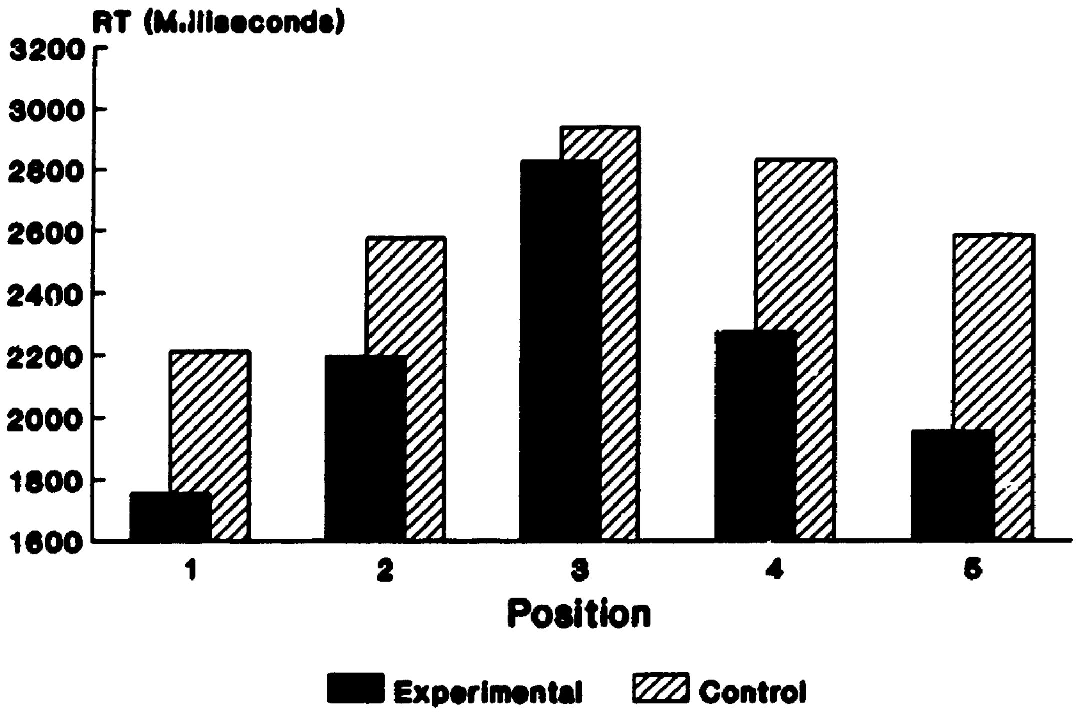


Figure 22. Mean RT for Self-Reference pairs as a function of Self-Referencing and Position in Experiment 3.

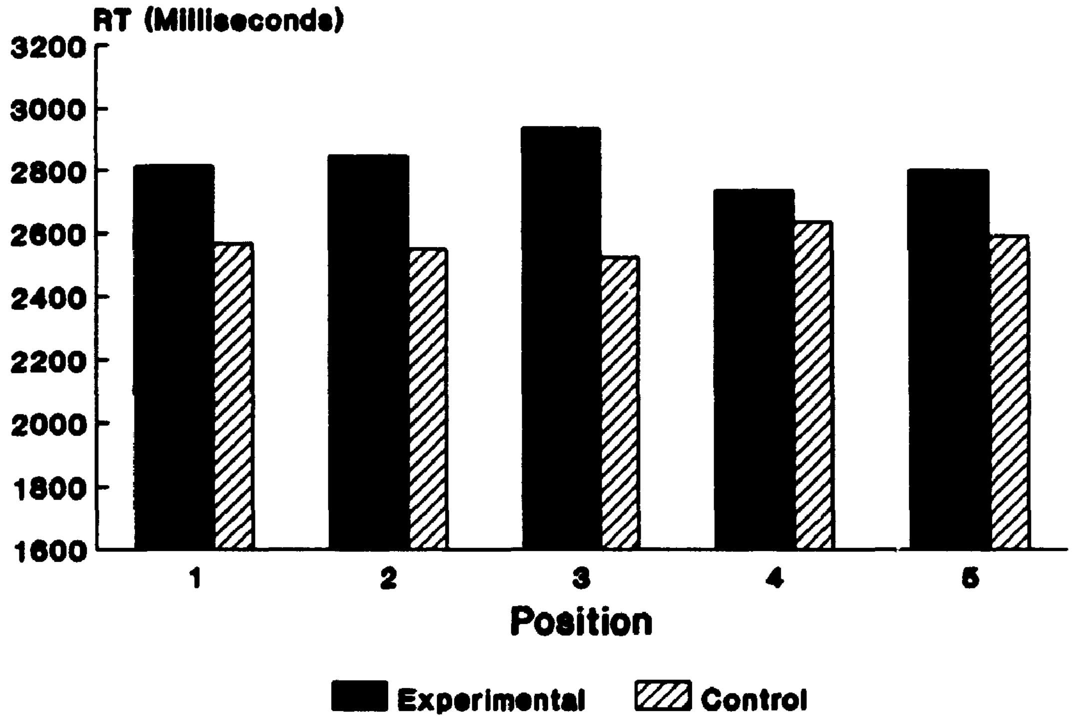


Figure 23. Mean RT for Other pairs as a function of Self-Referencing and Position in Experiment 3.

Table 29

5 (Position of Self-Referencing) X 2 (Self-Referencing) X 2 (Pair Type) ANOVA Table: Experiment 3

Dependent Variable: Mean RT

Independent Variables:

Between Factor (A) -- Position of Self-Referencing

A_1 - Position 1
A_2 - Position 2
A_3 - Position 3
A_4 - Position 4
A_5 - Position 5

Within Factor (B) --- Self-Referencing

B_1 - Experimental Condition
B_2 - Control Condition

Within Factor (C) ---- Pair Type

C_1 - Self-Reference Pairs
C_2 - Other Pairs

SOURCE	SS	DF	MS	F	P
between					
A	12465950.39	4	3116487.6	2.24	.069
S(A)	160307268.4	115	1393976.2		
within					
B	532814.40	1	532814.40	1.71	.194
AB	1805559.33	4	451389.83	1.44	.224
BS(A)	35926101.70	115	312400.88		
C	11438334.44	1	11438334.44	70.68*	.000
AC	10807108.96	4	2701777.2	16.70*	.000
CS(A)	18609855.98	115	161824.83		
BC	12159897.58	1	12159898.58	54.90*	.000
ABC	120735.55	4	30183.89	.14	.969
BCS(A)	25473653.84	115	221510.03		
Pooled	61399755.54	230	266955.46	[BS(A) & BCS(A)]	
B at C_1	8891737.80	1	8891737.80	33.31*a	
B at C_2	3800974.19	1	3800974.19	14.24*	

Note. [a]$F_{.10/2;1,223}$ = 3.89

The means and standard deviations of these RTs are shown in Table 30.

Table 31 gives the results from a 5 (Position of Self-Referencing) X 2 (Self-Referencing) X 4 (Serial Position) ANOVA. A significant Serial Position main effect was evident, $F(3, 306) = 35.98$, $p < .001$. The interaction between Serial Position and Position of Self-Referencing was also significant, $F(12, 306) = 3.46$, $p < .001$, as was the three-way interaction, $F(12, 306) = 4.19$, $p < .001$.

Figure 24 is a plot of means for the control condition, in which the five Position groups were pooled. As shown in Figure 24, there was a clear serial position effect in the control condition, with A-B and D-E pairs from the two ends having the shortest RTs, following by C-D and then B-C pairs.

Using the serial position curve from the control group as a comparison, the serial position curves for the experimental condition under the five different positions of the "You" term: that is, 1 (A), 2 (B), 3 (C), 4 (D) and 5 (E), are shown in Figures 25, 26, 27, 28 and 29 respectively. Similar to the results of previous experiments, the serial position curves changed according to the position in which the "You" term was placed. As shown in Figure 25, when the "You" term was at the first position, the first endpoint (A) effect was more robust. When the "You" term was placed at the second (B) position, RTs for A-

Table 30

Means and Standard Deviations of RT (in milliseconds) for Adjacent Pairs as a Function of Self-Referencing and Position: Experiment 3

		Serial Position			
Position		A-B	B-C	C-D	D-E
1 (A) n = 21					
Experimental	M	1670.61	2866.91	3195.76	2633.97
	SD	612.20	902.79	1207.20	1170.55
Control	M	2187.56	2909.84	3005.17	2125.92
	SD	835.13	999.43	941.78	825.02
2 (B) n = 23					
Experimental	M	1970.13	2324.50	3487.71	3026.33
	SD	659.907	1138.68	1176.23	1391.37
Control	M	2119.43	2825.78	2774.62	2732.79
	SD	716.62	1086.18	889.51	1211.08
3 (C) n = 20					
Experimental	M	2823.28	3033.55	3310.70	3183.29
	SD	1347.33	1415.48	1262.93	1251.51
Control	M	2456.09	3619.98	3178.48	2531.72
	SD	819.44	1770.30	948.26	1301.90
4 (D) n = 23					
Experimental	M	2736.44	3483.36	2486.96	2235.20
	SD	873.71	1530.25	1036.39	707.22
Control	M	2701.17	3328.85	3328.32	2499.25
	SD	877.86	1113.05	1020.16	1242.16
5 (E) n = 20					
Experimental	M	2505.15	2811.53	3194.07	1977.04
	SD	727.97	749.43	794.35	642.30
Control	M	2116.78	3010.07	2916.87	2618.02
	SD	680.32	1010.53	694.85	1131.38

Table 31

5 (Position of Self-Referencing) X 2 (Self-Referencing) X 4 (Serial Position) ANOVA Table: Experiment 3

Dependent Variable: Mean RT

Independent Variables:

Between Factor (A) -- Position of Self-Referencing

A_1 - Position 1
A_2 - Position 2
A_3 - Position 3
A_4 - Position 4
A_5 - Position 5

Within Factor (B) --- Self-Referencing

B_1 - Experimental Condition
B_2 - Control Condition

Within Factor (C) ---- Serial Position

C_1 - A-B
C_2 - B-C
C_3 - C-D
C_4 - D-E

SOURCE	*SS*	*DF*	*MS*	*F*	*P*
between					
A	20441468.89	4	5110367.2	1.55	.195
S(A)	337305552.8	102	3306917.2		
within					
B	472098.03	1	472098.03	.50	.482
AB	4307210.86	4	1076802.7	1.13	.345
BS(A)	96834287.03	102	949355.76		
C	92486834.57	3	30828945	35.98*	.000
AC	35571137.96	12	2964261.5	3.46*	.000
CS(A)	262203383.3	306	856873.80		
BC	3712754.52	3	1237584.8	1.98	.116
ABC	31387823.12	12	2615651.9	4.19*	.000
BCS(A)	190920795.6	306	623924.17		

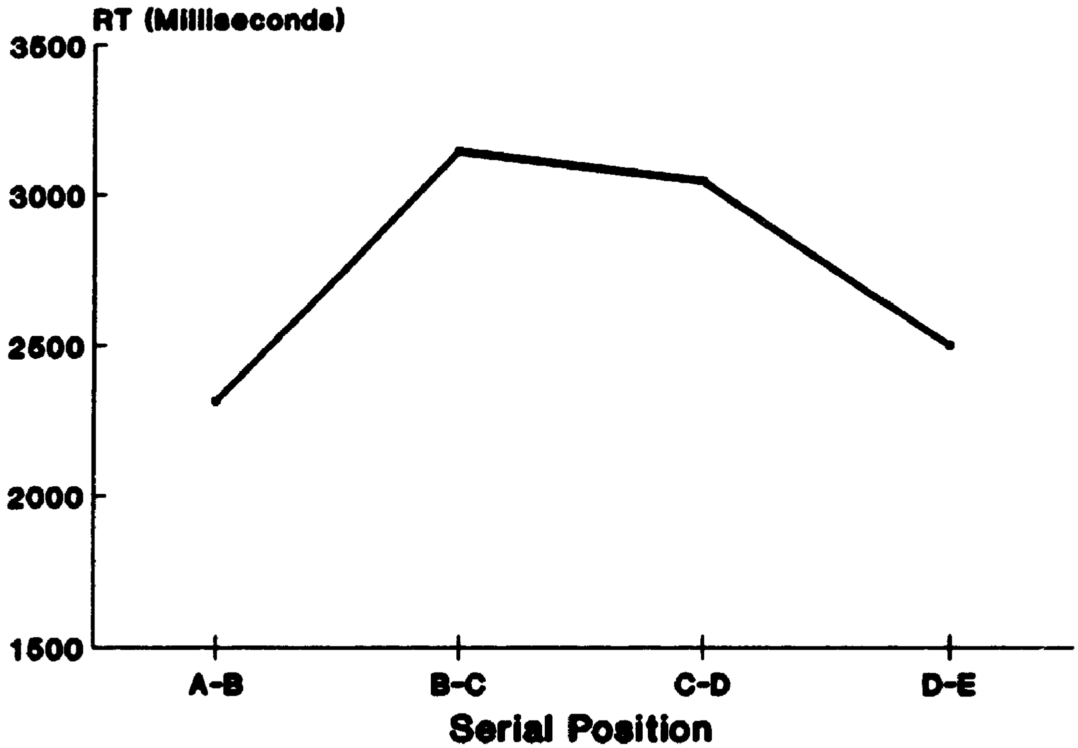


Figure 24. Serial position effect for the Control group: Mean RT for adjacent pairs as a function of serial position in Experiment 3.

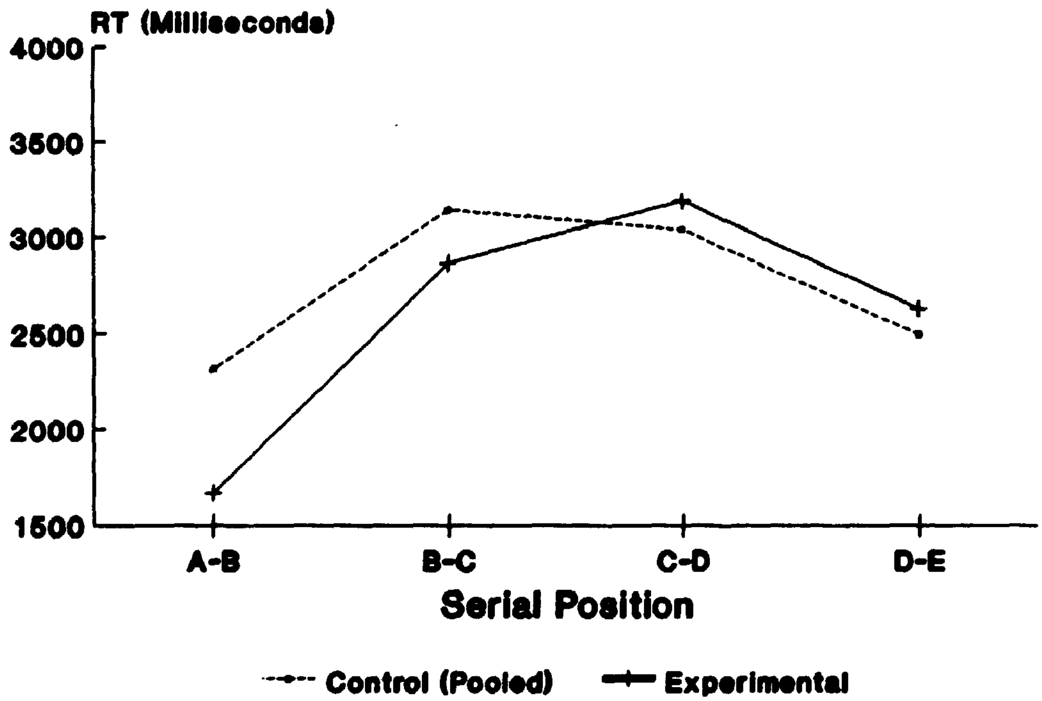


Figure 25. Serial position effect for the Experimental condition in Position 1 (A) group: Mean RT for adjacent pairs as a function of serial position in Experiment 3.

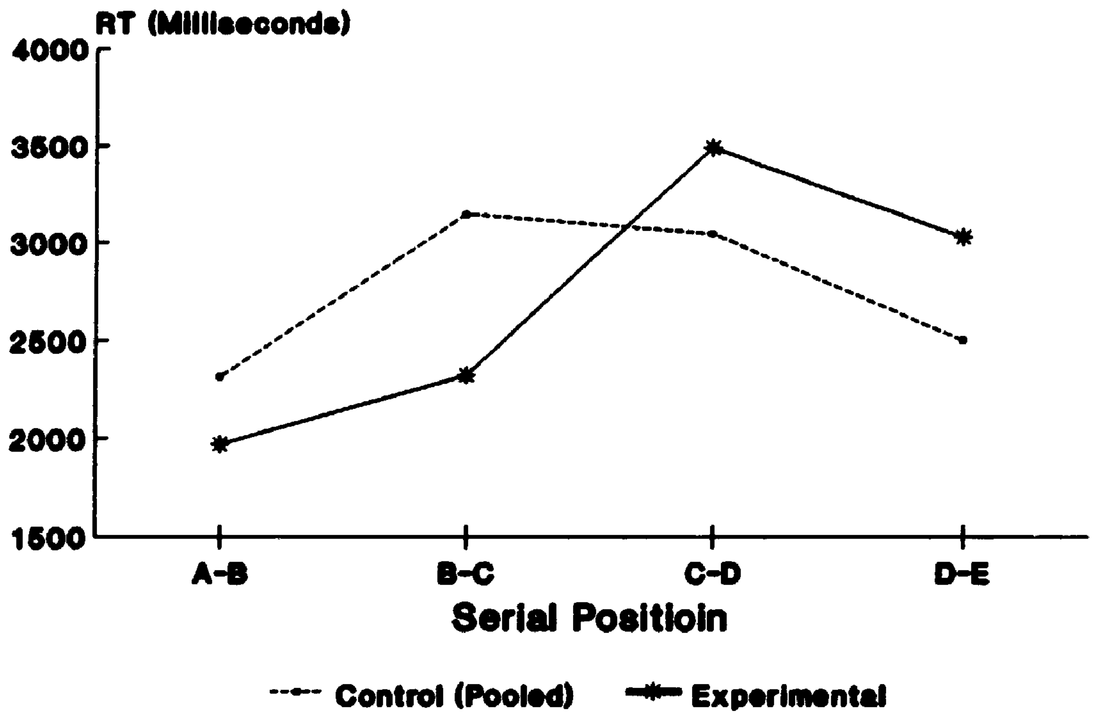


Figure 26. Serial position effect for the Experimental condition in Position 2 (B) group: Mean RT for adjacent pairs as a function of serial position in Experiment 3.

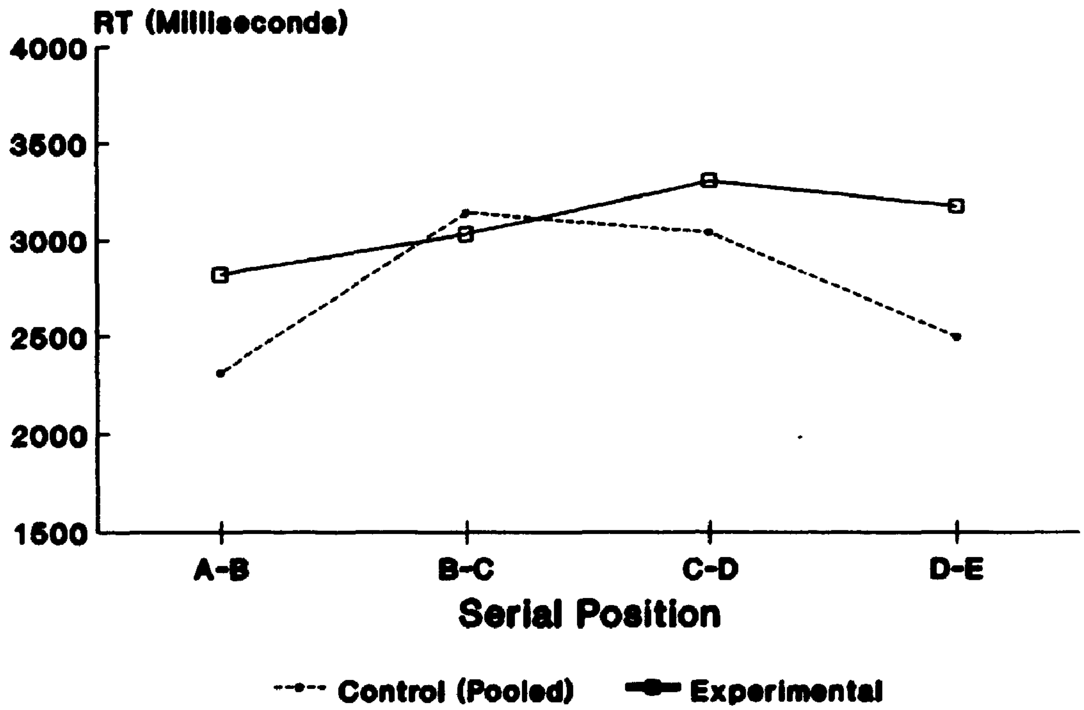
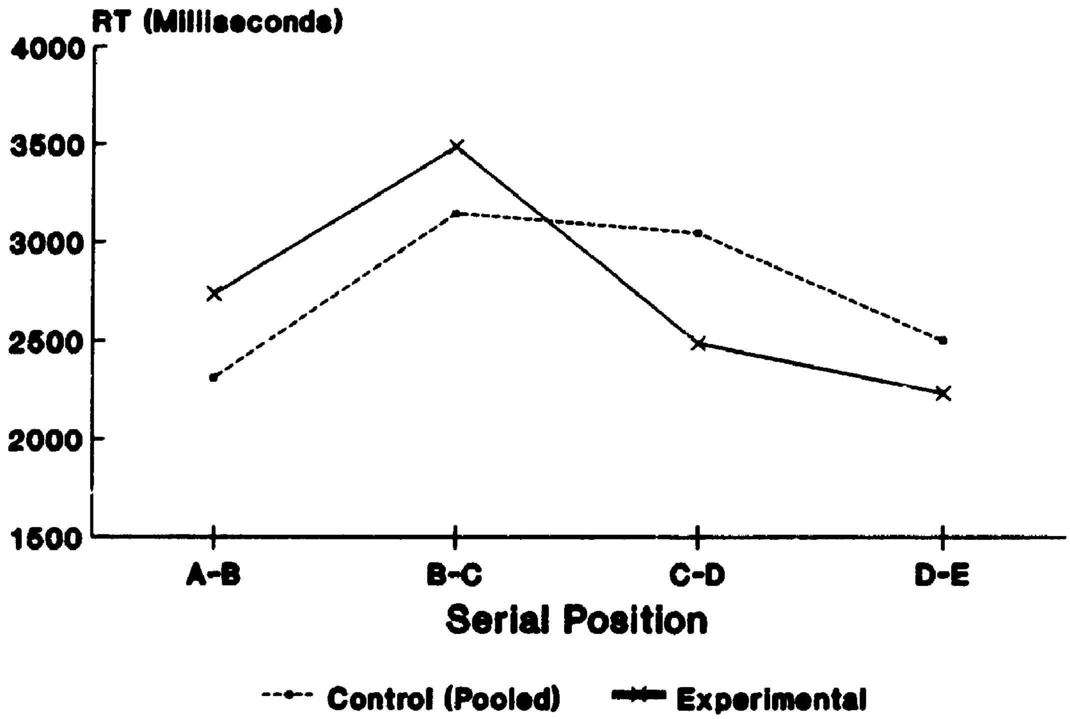


Figure 27. Serial position effect for the Experimental condition in Position 3 (C) group: Mean RT for adjacent pairs as a function of serial position in Experiment 3.



<u>Figure 28</u>. Serial position effect for the Experimental condition in Position 4 (D) group: Mean RT for adjacent pairs as a function of serial position in Experiment 3.

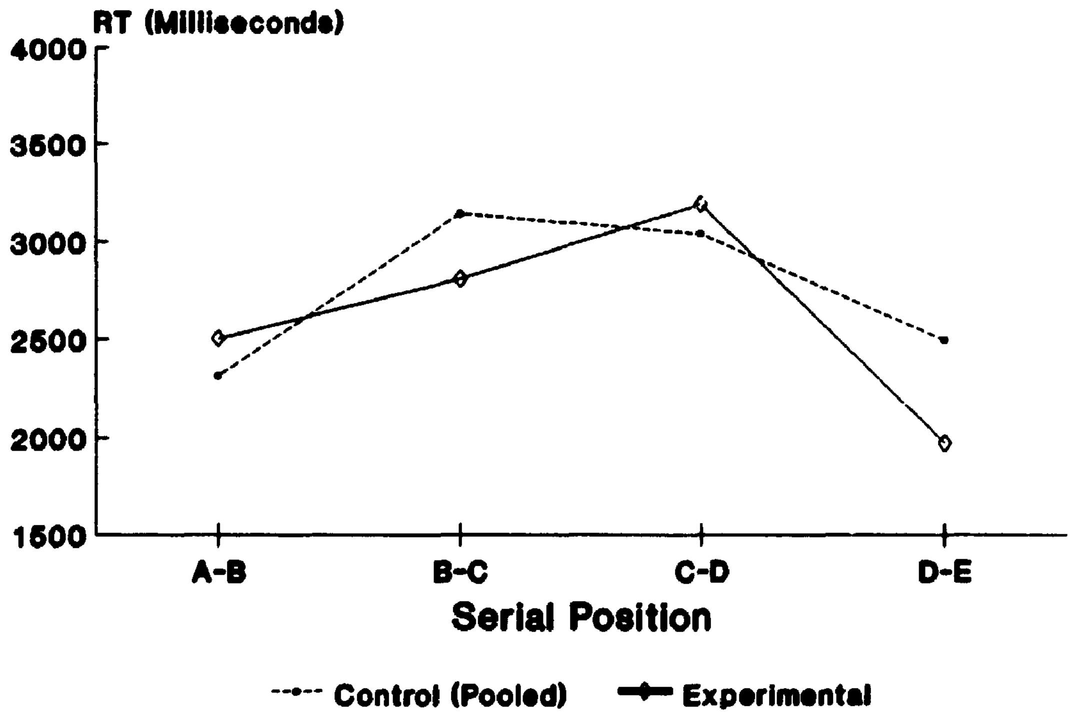


Figure 29. Serial position effect for the Experimental condition in Position 5 (E) group: Mean RT for adjacent pairs as a function of serial position in Experiment 3.

B and B-C pairs were the shortest following by D-E then C-D pairs (See Figure 26). These behaviour patterns were similar for the conditions where "You" was at the fifth (E), and fourth (D) positions, as shown in Figure 29 and 28 respectively. When the "You" term was placed at the third (C) position, as shown in Figure 27, the line became more or less flat. The serial position effect disappeared under this condition.

Distance effect. The distance effect was tested by excluding pairs containing one or more endpoints. The 6 inner pairs were classified to be either 1-step or 2-step. Table 32 shows means and standard deviations of RTs for these two types of pairs. In the control condition, as shown in Figure 30, the 2-step pairs had slightly shorter RTs than the 1-step pairs for all 5 position groups. In the experimental condition, the 2-step pairs had shorter RTs than the 1-step pairs for Position 1, 2, and 4 groups. However, for Position 3 and 5 groups, the direction was reversed (See Figure 31).

A 5 (Position of Self-Referencing) X 2 (Self-Referencing) X 2 (Distance) ANOVA showed a significant Distance main effect, $F(1, 113) = 10.60$, $p < .001$. The interaction between Distance and Position was also significant, $F(4, 113) = 2.79$, $p < .03$, as was the three way interaction, $F(4, 113) = 3.27$, $p < .014$ (See Table 33).

Further analysis of the simple main effects of Distance

Table 32

Means and Standard Deviations of RT (in milliseconds) for 1-step and 2-step Inner Pairs as a Function of Self-Referencing and Position: Experiment 3

Position		Condition: Experimental	Condition: Control
1 (A) n = 23			
1-step pairs	M	3103.18	2920.38
	SD	869.29	789.20
2-step pairs	M	2742.75	2789.09
	SD	1100.52	1076.80
2 (B) n = 24			
1-step pairs	M	289[illegible].07	2773.70
	SD	975.27	859.97
2-step pairs	M	2308.05	2722.09
	SD	941.18	1098.51
3 (C) n = 24			
1-step pairs	M	3163.02	3334.84
	SD	1234.93	985.99
2-step pairs	M	3517.53	3122.52
	SD	1014.00	823.20
4 (D) n = 24			
1-step pairs	M	2890.10	3336.11
	SD	956.78	836.37
2-step pairs	M	2273.70	3001.92
	SD	664.56	931.13
5 (E) n = 23			
1-step pairs	M	2993.26	2998.54
	SD	684.74	752.32
2-step pairs	M	3252.39	2715.76
	SD	912.20	768.27

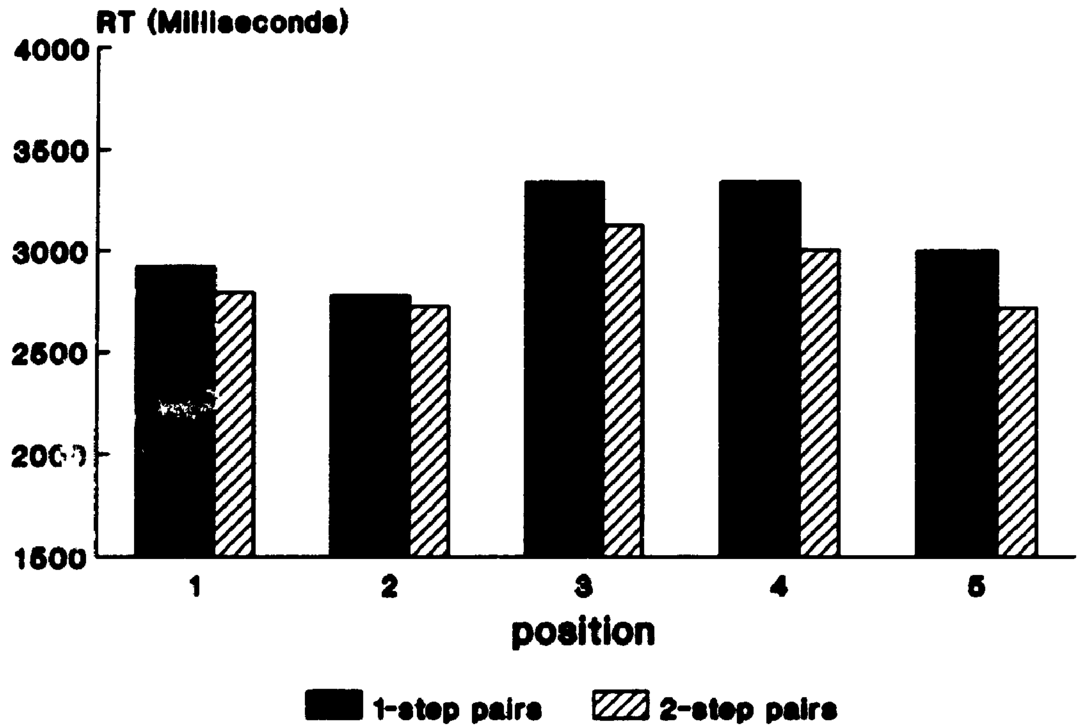


Figure 30. Distance effect for the Control condition: Mean RT for 1-step and 2-step pairs as a function of Position in Experiment 3.

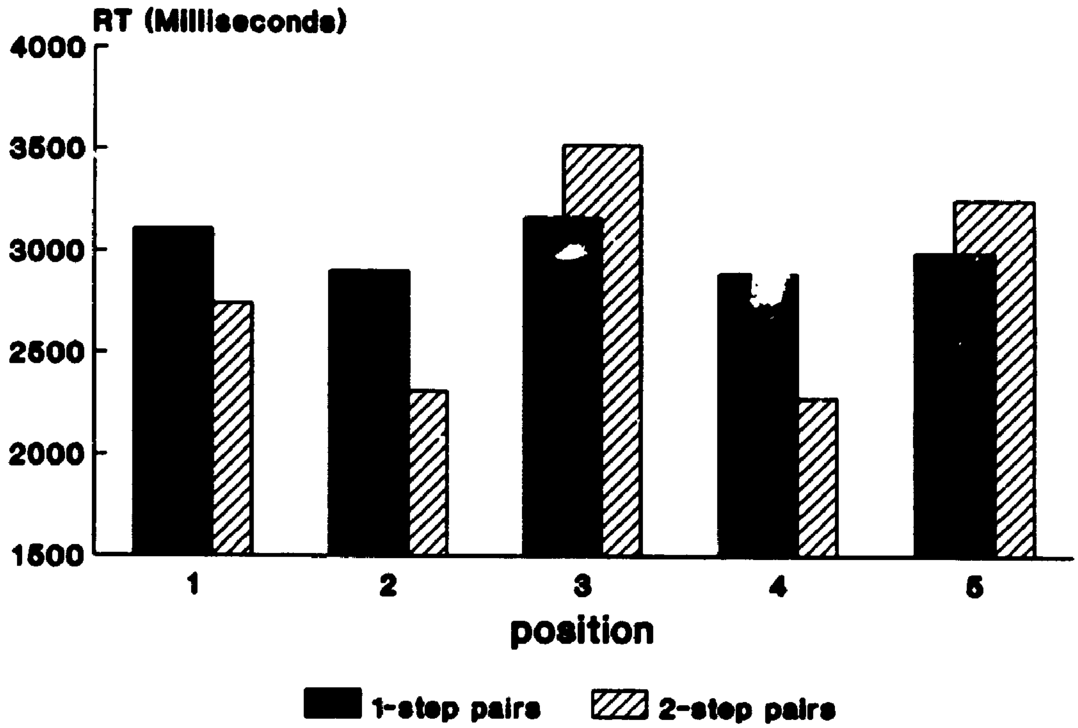


Figure 31. Distance effect for the Experimental condition: Mean RT for 1-step and 2-step pairs as a function of Position in Experiment 3.

Table 33

5 (Position of Self-Referencing) X 2 (Self-Referencing) X 2 (Distance) ANOVA Table: Experiment 3

Dependent Variable: Mean RT

Independent Variables:

Between Factor (A) -- Position of Self-Referencing

A_1 - Position 1
A_2 - Position 2
A_3 - Position 3
A_4 - Position 4
A_5 - Position 5

Within Factor (B) --- Self-Referencing

B_1 - Experimental Condition
B_2 - Control Condition

Within Factor (C) --- Distance

C_1 - 1-Step Pairs
C_2 - 2-Step Pairs

SOURCE	SS	DF	MS	F	P
between					
A	18962729.34	4	4740682.3	2.43	.051
S(A)	220020913.1	113	1947087.7		
within					
B	385774.90	1	385774.90	.66	.417
AB	10363377.00	4	2590844.2	4.45*	.002
BS(A)	65727441.13	113	581658.77		
C	4560774.21	1	4560774.21	10.60*	.001
AC	4798219.31	4	1199554.8	2.79*	.030
CS(A)	48640258.05	113	430444.70		
BC	6933.06	1	3966.06	.01	.927
ABC	6139383.68	4	1534845.9	3.27*	.014
BCS(A)	53080001.07	113	469734.52		
Pooled	101720259.12	226	450089.64	[CS(A) & BCS(A)]	
C at A_1B_1	1493927.08	1	1493927.08	3.18[a]	
C at A_2B_1	4191642.9	1	4191642.9	9.31*	
C at A_3B_1	1508116.86	1	1508116.86	3.35	
C at A_4B_1	4559402.93	1	4559402.93	10.13*	
C at A_5B_1	772219.47	1	772219.47	1.64	
C at A_1B_2	198225.8	1	198225.8	.44	
C at B_2B_2	31962.33	1	31962.33	.07	
C at A_3B_2	540928.02	1	540928.02	1.20	
C at A_4B_2	1340245.05	1	1340245.05	2.98	
C at A_5B_2	919609.04	1	919609.04	2.04	

Note. $^{a}F_{.10/10;1,226} = 6.76$

revealed that for the control condition, Distance did not have a significant effect for any Position group. However, for the experimental condition, two of the five simple main effects were found to be significant, namely that for the Position 2 group, $F(1, 226) = 9.31$, and that for the Position 4 group, $F(1, 226) = 10.13$.

Self-report data on strategy use and self referencing. As noted above, after each task subjects typed in the ordering of the names that they used in answering the questions. After all the tasks were completed, three questions were presented. Subjects were asked to report any use of strategies, then to indicate whether they referred the "You" term to themselves, and finally to judge whether inserting the "You" term in the task was facilitative.

For the first question, 50% of the 120 subjects reported that they did not use any strategies other than repetition. Among those subjects who did use strategies, the most common reported strategy, as in Experiment 2, was using the first letter of each name in an acronym to simplify the task. Thirty three percent of subjects reported the use of this strategy. Six subjects described that they isolated the ends first by identifying people who were at the two ends.

On the second question, 56.4% of subjects reported that they referred the "You" term to themselves. The other 43.6% of subjects indicated that they treated the "You" term as just another name. When asked to type in the sequence of names used in recalling linear ordering, 34 subjects actually used "Me", "I" or their own name to replace the "You" term.

For the subjects who referred the "You" term to themselves, 71.88% considered "You" as a facilitative factor, 21.54% said that it did not have any effect, and 7.69% considered inserting a "You" term as detrimental in that it made them more confused. Among those subjects who did not refer the "You" term to themselves, 20.41% still considered it as facilitative, 67.35% said that it had no effect, and 12.24% thought it was detrimental.

Overall, 48.3% of the subjects responded that the "You" term helped them in remembering the information and answering the questions, whereas 42.2% indicated that the "You" term did not affect them at all. Only 9.5% of subjects described that having a "You" term in the task somehow made the task more confusing and difficult.

Discussion

Though a different experimental design was applied in Experiment 3, most of the major findings of the previous experiments were replicated. Like the previous experiments, the results of the present experiment indicate that the inclusion of a "You" term in a linear ordering task does not have a significant main effect on overall performance. For the Experimental group, the Position effect appeared to be very similar to the one found in Experiment 2, although it only approached significance in the present experiment. When the "You" term was included in the task, the performance trend across the five position groups showed an inverted V trend. This finding confirms the notion that placing the "You" term in the endpoints as an anchor is most effective, and that the further away the "You" term is from the endpoints the worse the performance becomes.

Similar to the previous two experiments, Self-Referencing showed an interesting interaction with Pair Type. This interaction suggests that though Self-Referencing did not motivate subjects to have better overall performance in the present experiment, it did have an impact on the way subjects processed and stored information. For all five Position groups, RT for Self-Reference Pairs was shorter in the experimental condition than in the control condition. For the Other Pairs, however, the direction was reversed: for all five Position groups, RT was shorter in the control condition than in the experimental condition. In other words, although overall performance did not differ between the experimental condition and the control condition, within-task analyses showed a significant impact of Self-Referencing on the performance of different types of pairs. When there was a "You" term involved in the linear ordering, subjects tended to respond faster to questions relating to "You", but slower to the questions that do not include a "You" term. This behaviour pattern carried across the five groups where "You" was placed at different positions.

The serial position effects observed in Experiments 1 and 2 were also replicated in the present experiment. In testing the serial position effect, only one overall ANOVA was performed. No further contrasts of means were done. However, since the pattern was clear and consistent across all three experiments, a lack of detailed statistical analyses does not seem to pose any threat to the validity of this finding.

As in the previous experiment, subjects provided some descriptive data on their cognitive processing. Again, individual differences were found among the subjects in terms of their reported responses to the "You" term in the task. Further exploratory analyses, however, indicated that whether subjects reported they referred the "You" term to themselves or not did not seem to have a significant impact on their performance. A 5 (Position) X 2 (Reported Self-Referencing) ANOVA revealed no significant effect of Reported Self-Referencing, $F(1, 107)=.15$, $p > .05$. There was no significant interaction between Reported Self-Referencing and Position either $F(4, 107)=1.61$, $p >.05$. Indeed, in the condition where a "You" term was included in the task, the performance of subjects who referred the "You" term to themselves (M = 2554.70) did not differ from the performance of subjects who did not refer the "You" term to themselves (*M* = 2590.68). However, since this factor, Reported Self-Referencing, was not a preplanned variable in the present experiment, the appropriateness of these analyses in terms of statistical power remains a question. Therefore, these results can only be treated as exploratory and preliminary.

As suggested earlier, it is possible that subjects were not fully aware of their own cognitive processing. In other words, although subjects reported that they did not refer the "You" term to themselves, it is conceivable that self-referencing did in fact occur. It is also possible that for those subjects who reported no self-referencing, the distinctive nature of the "You" term was the cause of changes in cognitive processing. If the latter hypothesis is true, using distinctive words other than "You" in the task might be able to produce similar effects as observed in the present research. Further studies are required to clarify the mechanism of the self-referencing effect as observed in the present research.

From an educational point of view, however, it is clear that using the word "You" in a task is sufficient in changing students' cognitive processing. In the present experiment, most subjects who reported use of self-referencing responded favourably toward the condition, and considered having a "You" term in the task as an facilitative factor. Indeed, referring to students with the word "You" and including the "You" term in the task might be the easiest way teachers can use to bring students' personal involvement in the task, and to attract, direct and guide students' attention.

The results of the present study do not provide support for hypotheses concerning the distance effect. Although 2 step-pairs had shorter RTs than 1-step pairs for all five position groups in the control condition, none of these differences was significant. Combining the results from the previous two experiments, it appears that distance does not have a significant impact on RT in the 5-term linear ordering task used in this research.

In the experimental condition, the distance effect was significant for the Position 2 and Position 4 groups. For these two groups, the 2-step pairs had a shorter RT than the 1-step pairs. However, since the results from all tests indicate that subjects use the "You" term as a focus to organize information, it is very possible that these significant distance effects are confounded with the self-focusing effect. That is, for the Position 2 and Position 4 groups, when "You" is involved in the linear ordering, all the inner 2-step pairs have the "You" term as a focus, but only half of the 1 step pairs have this self-focusing term. Therefore, it is perhaps not appropriate to take this finding as evidence supporting the hypothesized distance effect.

General Discussion

The present research tested effects of self-referencing on a 5-term linear ordering task. The results obtained from the three experiments were consistent. In general, including a "You" term in the task did not produce a significant overall effect on subjects' performance. However, the Position effect and the interaction of Self-Referencing with other variables indicated that self-referencing did have a significant impact on cognitive processing. When test questions were related to the self term, the reaction times were shorter, whereas when questions did not involve a self term, performance deteriorated. Also, including the "You" term in the various positions on the linear ordering appeared to result in different levels of performance. That is, the further away the "You" term was from the endpoints, the worse performance became. Moreover, observation of the serial position curves provided evidence that the endpoint effect changes according to the position of the "You" term.

Cognitive Effects of Self-Referencing

The results of the three experiments reported in this thesis are consistent with the view that people tend to use "self" terms as a focus in organizing information. Particularly, the tests on serial position effect indicate that people shift their focuses for organizing linear ordering to wherever the "You" term is positioned. This self-focusing effect is so strong that if the "You" term is placed at the middle of the 5-term linear ordering, it diminishes the normal endpoint effects.

Moreover, when self-focusing is applied, people become much more effective in responding to the questions that relate to self. This advantage on self-reference information, however, appears to be at the expense of other types of information. Findings from the present study show that when a question does not directly relate to the self term, the reaction times become longer.

Implications on End-Term Anchoring Theory

The present research provides new information on how linear orderings are stored and processed, particularly when a salient focus is introduced. Specifically, this study provides evidence that different memory representations are made with different focuses. Traditionally, studies using artificial linear ordering information show strong evidence of "ends-inward" construction of information. In the present three experiments, this traditional serial position effect was replicated only in the control condition where no "You" term is involved. Apparently this ends-inward memory representation can be easily altered by directing people to use different focuses. The serial position effects observed across different "You" positions in the experimental condition provide strong evidence for this change in memory representation.

On the other hand, it is not without good reason that people normally tend to use an ends-inward strategy to organize information on a linear ordering task. Results from the present research indicate that endpoint anchoring is the most effective way to organize linear ordering information. When people are cued to use the endpoints as anchors, that is, when the "You" term is positioned at the two ends, the overall performance was best compared to conditions where the "You" term was placed at other positions. Moreover, it seems that the further away the focus is from the ends, the worse the performance becomes. This observation implies that the most efficient strategy is to use the endpoints as the anchors or focuses.

Lack of Distance Effect

Potts (1974) reported the existence of distance effects in a linear ordering task even when endpoint effects were eliminated. In the Potts study, a 6-term linear ordering task was used. The pair-wise comparison on the 4 inner terms provided evidence for the distance effect. In the present research, the test of the distance effect was constantly unsuccessful. For all three experiments, distance did not seem to play a significant role in RT differences for the inner pairs.

One possible explanation for this difference in findings is that the linear ordering used in Potts study had one more term than that used in the present experiments.

Therefore, the remote pairs in the Potts study included both 2-step and 3-step test pairs, whereas the biggest distance between these inner pairs in the present experiment was 2 steps. This greater magnitude of remoteness in the pair comparison may be the main reason for the significant finding of the Potts study.

Moreover, subjects were tested on 12 paragraphs in the Potts study with no special manipulation involved. Compared to the present experiments, the number of trials was much greater and possibly subjects' use of strategy was much more consistent across the tasks. In this sense, the Potts study was a much more powerful test of the distance effect. Indeed the results from Experiment 3 in the present research showed that for the control condition, the 2-step pairs consistently had a shorter RT than the 1-step pairs across different groups. However, the magnitude of this difference was too small to be significant.

Implications for Instruction

Though the self-referencing effect on overall performance was not significant in the present research, this finding should not be taken to diminish the possible motivational impact of self-referencing in education. The present experiments were conducted in a laboratory setting. Subjects were encouraged to do their best to respond as fast as possible to all the test questions. Therefore, there is a strong possibility that most of the subjects were already highly motivated to perform well on the task. If subjects' motivation had already reached a ceiling effect, it is natural that the motivational impact of self referencing would not reveal itself in these experiments.

A motivational ceiling effect, however, is not a common phenomenon in a day-to-day classroom setting, where one of the main tasks for teachers is to keep students motivated. Since past research has shown that students have more positive attitudes toward learning when the examples given were personalized, the motivational impact of self referencing in educational settings should not be undermined.

The cognitive effects of self referencing have strong implications for teaching. One clear and consistent finding is that the word "You" can be used to direct students' attention. The results from the present research suggest that when personally involved, students may use the "self" as a focus in organizing information. Moreover, the results indicate that self-referencing does in fact lead to improved performance in a linear ordering task, provided that follow-up test questions also involve self-referencing. Although facilitative effects of self-referencing were found only under limited conditions, it could be argued that these conditions are the ones most likely to be found in normal classrooms. In other words, the most likely scenario is that a teacher presents a problem or fact involving self-referencing, and then asks a test question that also involves self-referencing. This supposition gives greater credibility to the applicability of the present findings to real students in real classrooms. Furthermore, it should be noted that one possible reason for the consistently positive findings of prior studies of self-referencing in mathematics education (e.g., Arnand & Ross, 1987; Davis-Dorsey, Ross & Morrison, 1991; Wright & Wright, 1985) is that the tasks used in prior research generally involved self-referenced test questions. Thus, the present results are consistent with previous evidence that self-referencing is beneficial, but the present results indicate that this beneficial impact is found only when self-referenced educational materials are followed by self-referenced questions relating to those materials.

As noted above there are instances where it is inappropriate to use the "You" term in a mathematics problem. The present research suggests that the advantage gained in answering self-reference questions appear to be at the expense of questions tapping other types of information. When a question does not directly relate to the "self" term, students' reaction times become longer. This finding indicates that if self-referencing is applied in the classroom, students would tend to focus more on self-related information, and less on other types of information. Therefore, if a "You" term is incorporated in the problem but the test questions do not directly refer to it, there may be a detrimental effect. Since self-referencing could be damaging if it is not used appropriately, educators should be cautious when applying it. If the goal is to facilitate students' performance, teachers should avoid bringing personal reference in a problem while the focus of the question is unrelated to self-reference information.

Most of the studies on mathematics word-problem solving, as described in the introduction, applied computer technology to fit individual differences. Personal information was obtained and incorporated into the problem context. The positive effect found in these studies is very promising and encouraging for mathematics teachers. This strategy of incorporating personal information in a problem context, however, is very difficult for teachers to apply in a classroom setting. Findings from the present research implies a easy solution. That is, simply using the word "You" in the problem may be sufficient to bring personal involvement of the student into the task and to direct students attention to an appropriate focus in a task.

<u>Implications for Further Research</u>

The present research used university students to test the effect of self-referencing on a 5-term linear ordering task. Since this research is relatively novel, further research on the generalizability of the findings to younger students and to other types of tasks will be necessary.

Developmental studies on the self referencing effect would be one way to pursue this research further. According to Piagét (1965), egocentrism is one of the characteristics of younger children. It is possible that the self-referencing effect is more robust in younger children than in university students.

When properly used, self-referencing can be a facilitator in information processing. Thus, it may be applied as an effective teaching strategy in introducing new mathematics concepts. This type of research could provide important information both for educators and for cognitive theorists.

The theoretical mechanism underlying the self-referencing effect observed in the present study does not have a single, clear cut explanation. According to subjects' self-report data, not all of them referred to the "You" term as themselves, yet this difference did not seem to affect the results in the experiments. As postulated earlier, it might be that subjects were not fully aware of their own cognitive processing, and that self-referencing did in fact occur with all or nearly all subjects in the experimental condition, despite their claims to the contrary. Alternatively, it is possible that these subjects indeed did not apply self-referencing on the task, and that the word "You" actually only served as an perceptually distinctive term for them to use as a focus in processing the information. If this is true, self-referencing might be only one of several alternative means to direct attention and change people's cognitive processing. That is, the findings from these experiments may be contributed primarily from the "distinctiveness" nature of "self" or the "You" term. Further research is necessary to test these competing hypothesis, although from an applied or educational perspective, self-referencing can be implemented in purely operational terms without knowing its theoretical basis.

The cognitive effects of self referencing could also serve as a basis for the testing of different cognitive models. For example, Sternberg and his colleagues (Sternberg, 1980a; Sternberg, 1980b; Sternberg & Weil, 1980) have done research on linear syllogistic reasoning in children and adults (e.g., John is taller than Mary. Mary is taller than Pete. Who is tallest? John, Mary, Pete). Several models were proposed to describe the representation and process in linear syllogistic reasoning. As shown in the present research, it is possible to use self referencing to direct people's attention to different terms. By applying this manipulation, it might help us understand whether and how the representation and process in linear syllogistic reasoning can be changed by the intervention of self referencing, and which model will be best to explain the phenomena.

Final Comment

The present research is a demonstration of how certain interventions change peoples' cognitive processing strategies in a task that simulates certain aspects of mathematics education. The interest of this research stems from observations in education. Indeed, intervention and change in cognitive processing are at the heart of instruction. Observations in educational research provide excellent resources for further cognitive investigation. On the other hand, research in cognitive psychology provides an excellent ground for educational researchers. Therefore, there is a great potentiality of bridging educational and cognitive research. Both fields are in a good position to make important contributions to the other.

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