THE EFFECT OF PRIORITIZATION

IN INFORMATION PROCESSING

By
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TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

When listening to messages from the mass media, we may find that certain facts grab our attention – perhaps because we find them especially relevant. It is likely that we will remember these facts, but how does their attention-grabbing nature impact our memory for other information contained within the same broadcast? Do we just forget this other information? Because we are surrounded by overwhelming amounts of information, we tend to select and prioritize information that we consider to be important. Notably, visual working memory studies have shown that of the consequences such prioritization on processing of other information can be different according to the situation. Given this, our study examined how people's information prioritization affects the memory of other unselected information. We asked people to listen to a passage about a fictional man, "Jack," in order to decide whether to bet on him or against him in the first round of a tennis tournament. For half of the participants, this passage never contained any information relevant to their decision (that is, no information about tennis). For the other half of participants, a single piece of tennis-relevant information appeared midway through the passage. We compared the memory of people who heard only task-irrelevant statements with the memory of

people who heard the one task-relevant word in the middle of the statements. Results revealed that after people heard the task relevant word, their memory for immediately following information was impaired. In contrast, their memory for information that preceded the relevant word was enhanced. These results have implications not only for our understanding of memory, but also for the design of messages for a listening public. For example, the data suggest that it might be effective to locate particularly important messages before the most attention capturing aspect of a message rather than after it, in order to ensure that these messages are remembered.

Chapter 1

INTRODUCTION

1.1 Prioritizing Information in Everyday Life

Imagine that you are listening to political advertisement on the radio, trying to decide whether or not to vote for a particular candidate. It tells you many facts about the candidate, but it is hard to remember them all. You heard several statements that you think are important to your decision, such as a candidate's accomplishments and opinions about a medical insurance policy, and you prioritized and remembered those statements that you considered relevant. What happens to all other information that you did not prioritize? Does the act of prioritizing some information cause you not to remember other information?

We are often overwhelmed by the amount of information around us, which exceeds our cognitive capacity. Therefore, whenever we recieve information from the world around us, we must be able to prioritize relatively meaningful information. In this respect, our perception, decisions, and behaviors are influenced by our goal-directed prioritization of information.

Mass media usually try to develop messages that can be prioritized in target audiences' minds. For example, dramatic features such as violence, sex and obscenity have been widely used in advertising, film, news media, and communication campaign in various ways to influence target audiences' opinions and attitudes (Fishbein, Hall-Jamieson, Zimmer, Haeften & Nabi, 2002; Reichert & Carpenter, 2004; Aust & Zillmann, 1996). Some political candidates use demagoguery to create messages that stick in voters' minds. For instance, demagogic appeals such as popular prejudices and false claims have been used to change voters' attitudes and voting behaviors (Lichtman & Most, 2007).

However, the precise costs and benefits of prioritization have been unclear. What happens to other unselected information after people prioritize certain information?

1.2 Selective Attention and Prioritization

Selective attention has long been recognized as a cognitive tool that is necessary for the prioritization of subsets of information. Neural evidence has shown that selective attention influences how neurons of the human sensory system effectively manage multiple stimuli in the world (Yantis, 2008). For example, the human visual system cannot represent all visual stimuli in a person's receptive field,

so selective attention determines what will be represented by swaying the response of neurons in the receptive fields. Therefore, selective attention plays a role in prioritizing a limited amount of information for further processing.

Decades of research have demonstrated the processing benefits of attention. Using an *attentional cueing* procedure, in which participants selectively pay attention to a cued location in order to quickly detect a target, a substantial number of visual cognition studies have demonstrated that visual attention can be shifted independently of eye movements. The shifting of attention can be *transient* – in that its benefits emerge quickly but fade disappears rapidly as well, or can be *sustained* – in that its benefits persist to aid with a person's behavioral goals (Most & Simons, 2001). Salient features of stimuli such as novelty, distinctiveness, or emotion are more likely to trigger involuntary transient orienting, though they may differ in their relative effectiveness in eliciting an orienting response (Most & Simons, 2001; Bradley, 2009). In contrast, task-relevant items are more likely to cause voluntary *sustained* orienting to keep person maintain their goals, even when the items are not particularly salient. Bradley (2009) pointed out that both involuntary, transient and voluntary, sustained orienting can be equally adaptive for survival. In this respect, to function well in life, humans should be able to prioritize relatively important information by effectively

allocating or disengaging attention to stimuli (Most & Jungé, 2008).

The processing of prioritized information has been known to be superior to that of non-prioritized information. For example, in one study, participants were cued to pay attention to a location where a target might occur with high probability (Posner, 1980). However, sometimes the cue appeared in a location away from the target. Participants' task was to detect and respond to the target as quickly as possible. It turned out that participants were faster to respond to a stimulus occurring at cued location, compared to the uncued locations. Posner referred to the increase in response speed as the "attentional benefit." Similarly, when Bashinski and Bacharach (1980) explicitly asked participants to report whether a stimulus had occurred, where it occurred, and how confident they were in their report of the stimulus, results showed that prioritization actually did produce benefits in perceptual processing.

1.3 Prioritization and *Working Memory*

Enhanced processing of prioritization of information is linked to working memory (WM) process. WM refers to the ability to hold internal representations in mind for a short period of time, and it is thought to serve as the basis for conscious report (Vogel, Woodman & Luck, 2006). As we can simultaneously pay attention to only a limited amount of information, only a limited amount of information can be

consolidated into a durable working memory representation. Therefore, the prioritization driven by selective attention is crucial for ensuring that important information is selected and consolidated into working memory.

Because selective attention is so closely tied to conscious awareness, prioritization of any given stimulus can cause us to miss a lot of other information that could not be prioritized. For instance, in a study by Neisser and colleagues (1979), participants watched a video of a group of people in white shirts passing a basketball and people in black shirt doing the same. Participants were instructed to attend to either the white or black team, and they pressed a key whenever that team made a pass. After 30 seconds, while participants were busy indicating the occurrence of passes, a woman carrying an open umbrella walked across the display and remained visible for approximately 4 seconds as she moved from one side to the other. Although participants were highly accurate in counting the number of passes, 75% of them missed the “umbrella woman”. This experiment demonstrated that when attention is preoccupied, even salient stimuli can be missed.

1.4 The Consequences of Prioritization

Visual cognition studies have demonstrated that the consequence of prioritization is not simply the enhanced perception and memory of prioritized

information and the impaired perception and memory of non-prioritized information, but such research has also shown that the consequences depend on the nature of the relationship between the prioritized and non-prioritized. For example, when participants searched for two targets in a rapid serial visual presentation (RSVP), the consequence of attending to the first target (T1) for the processing of the second target (T2) depended on their temporal relationship to each other: processing of the second T2 was disrupted by prioritization of T1 when T2 appeared within 200-400ms after T1 (Chun & Potter, 1995). However, if T2 appeared a longer time after T1, processing of it was not disrupted. In addition, Anderson (2005) showed that prioritization of T1 could also be impaired by T2 when T2 was an emotional word and the very next item.

Recently, Most and Jungé (2008) found the relatively automatic prioritization of a task-irrelevant emotional picture could distract or enhance prioritization of a target, depending on the precise conditions. In this study, participants searched for one rotated image in a rapid stream of pictures and each picture was presented for 100ms. The study showed that target processing was disrupted when the target appeared within 100ms before and 800ms after the emotional picture. However, when the target appeared 200ms before the emotional distractor, processing of the task-irrelevant

emotional picture actually enhanced processing of the target.

1.5 Present Study and Hypothesis

As an extension of Most and Jungé (2008) study, we examined the costs and benefits of a prioritization in a real world situation. Visual cognition studies have given some hints to the question of why and under which conditions can a message be used as a tool of influencing people's information processing. More evidence is needed, however, to apply these results from the visual domain to people's information processing in a non-visual situation and yield an answer to the question of why and how a message can affect people's information processing in a real world. In this study, we tested the impact of prioritizing a piece of information in the verbal domain on processing of other information within that domain. More specifically, we tested how a prioritization of a single task-relevant word embedded within a message influences participants' ability to process the other task-irrelevant words coming before or after the task-relevant word.

Consistent with Most and Jungé's (2008) findings, we hypothesized that prioritization of a single task-relevant word (a "critical" word) would impair processing of subsequent words, but would enhance processing of preceding words. Thus, we predicted that participants who heard the task-relevant word would be more

likely to forget information that appeared after the critical word (relative to participants for whom the task-relevant critical word was replaced in the message by a task-irrelevant word). In contrast, we predicted that participants who heard the task-relevant word would be more likely to remember words that preceded the critical word.

Chapter 2

METHODS

2.1 Participants

Participants were 72 University of Delaware undergraduate students (ages 18-22; 45 females). Data from four participants were subsequently excluded prior to the data analysis due to their missing answers or multiple answers in the memory test (described below), leaving 68 participants in all (ages 18-22; 43 females). Each student participated for course credit and gave informed written consent. The experiment was approved by the University of Delaware Human Subjects Review Board.

2.2 Materials & Procedure

Before beginning the task, printed instructions were given to all participants. Participants were told that they were about to hear a description of a hypothetical man, Jack, who would be playing in the first round of a regional tennis tournament. Participants were told that they would have up to 500 imaginary dollars that they could use either to bet for or bet against Jack. Participants were told that more they bet, the more they will win if they are right, but the more they will lose if they are wrong. The purpose of this goal-directed task was to establish the domain of "tennis"

as particularly relevant to the participants. Participants were told that after they heard all the statements, they would be asked to place their bet in favor of or against Jack. It was emphasized that participants should listen to the entire passage carefully.

The auditory message was composed of a series of statements about Jack (see Appendix 1). Participants were randomly placed into one of two conditions, the "Relevant" or the "Irrelevant" condition, which differed from each other only in the presence or absence of a single word: the passage in the Relevant condition included the word "tennis", whereas in the Irrelevant condition this word was replaced by the word "singing" (see Appendix 1).

Right after listening, participants were given a printed "Attentional Control" (AC) scale on which they were asked to report their ability to use attention in everyday life (Derryberry & Reed, 2002). Scores on the scale were irrelevant to the study; instead, completion of the scale was a time-filler, which was important to diminish what is known as a *recency effect,* wherein the most recently heard information is more likely to be remembered regardless of the characteristics of information. (e.g., Glanzer & Cunitz, 1966).

After filling out the AC scale, a printed questionnaire was given on which participants were asked how much they would bet on or against Jack in the first round

of a regional tennis tournament (see Appendix 2 for the questionnaire). There were six options: “500 dollars *against* Jack,” “100 dollars *against* Jack,” “20 dollars *against* Jack,” “20 dollars *favoring* Jack,” “100 dollars *favoring* Jack,” and “500 dollars *favoring* Jack.” Participants were asked to choose the one option that most reflected their attitudes.

Starting on the next page, participants received a surprise memory test for words that they may or may not have heard in the passage about Jack (see Appendix 2). For each word, there were four options: “1” was “definitely not heard,” “2” was “probably not heard,” “3” was “probably heard,” and “4” was “definitely heard.”

The questionnaire contained 50 words that actually had appeared in the passage and 27 words that had not appeared in the passage. The words that did not appear were included to prevent participants benefit from benefiting from a bias simply to say that they remembered the words. The critical words “tennis” and “singing” were not tested.

After participants finished, the experimenter checked that participants had responded to all items and participants were debriefed.

Chapter 3

RESULTS

Participants in the relevant condition had significantly more positive attitudes toward Jack than did participants in the irrelevant condition, $t(66) = 2.04$, $p = .046$. The average bet in the relevant word condition was $79.39 in favor of Jack, and the average bet in the irrelevant condition was $21.14 against Jack. This suggests that participants had indeed processed and taken into account the relevant word.

For analysis, tested words were numbered from 1 to 50 according to their order in the auditory passage (the test questionnaire had presented words in a randomized order). The words 24-25 and words 26-27 fall in what we labeled "Ground Zero", which means that they were the words that came either right before or right after the critical task-relevant or task-irrelevant word and that had appeared in the same sentence as the critical word. The words that came before the Ground Zero period were divided into two roughly equal clusters, as were the words that came after the Ground Zero period. That is, words 1-12 were grouped and averaged (word 7, "teacher", was excluded from the analysis because it had appeared in the passage twice), words 13-23 were grouped and averaged, words 24-25 were grouped and

averaged, words 26-27 were grouped and averaged, words 28-38 were grouped and averaged, words 39-50 were grouped and averaged.

For each word in the memory test, participants were asked to rate on a scale of "1" to "4" ("1" = definitely not heard, "2" = probably not heard, "3" = probably heard, "4" = definitely heard) how sure they were that the word had appeared in the message. Therefore, the higher the score, the more accurate they were.

Memory accuracy of words 1-12 in relevant condition (M = 2.87, SD = .50) was lower than those in irrelevant condition (M = 2.96, SD = .49), but this difference was not significant, t (66) = .82, p = .41. Memory accuracy of words 13-23 in the relevant condition (M = 3.31, SD = .41) was significantly higher than those in the irrelevant condition (M = 3.08, SD = .46), t (66) = 2.17, p = .03. Memory accuracy of words 24-25 in the relevant condition (M = 3.70, SD = .61) was lower than those in the irrelevant condition (M = 3.79, SD = .44), but this difference was not significant, t (66) = .69, p = .49. Memory accuracy of words 26-27 in the relevant condition (M = 2.53, SD = .87) was significantly lower than those in the irrelevant condition (M = 3.08, SD = .76), t (66) = 2.80, p = .007. Memory accuracy of words 28-38 in the relevant condition (M = 2.56, SD = .51) was significantly lower than those in the irrelevant condition (M = 2.91, SD = .50), t (66) = 2.83, p = .006. Memory accuracy

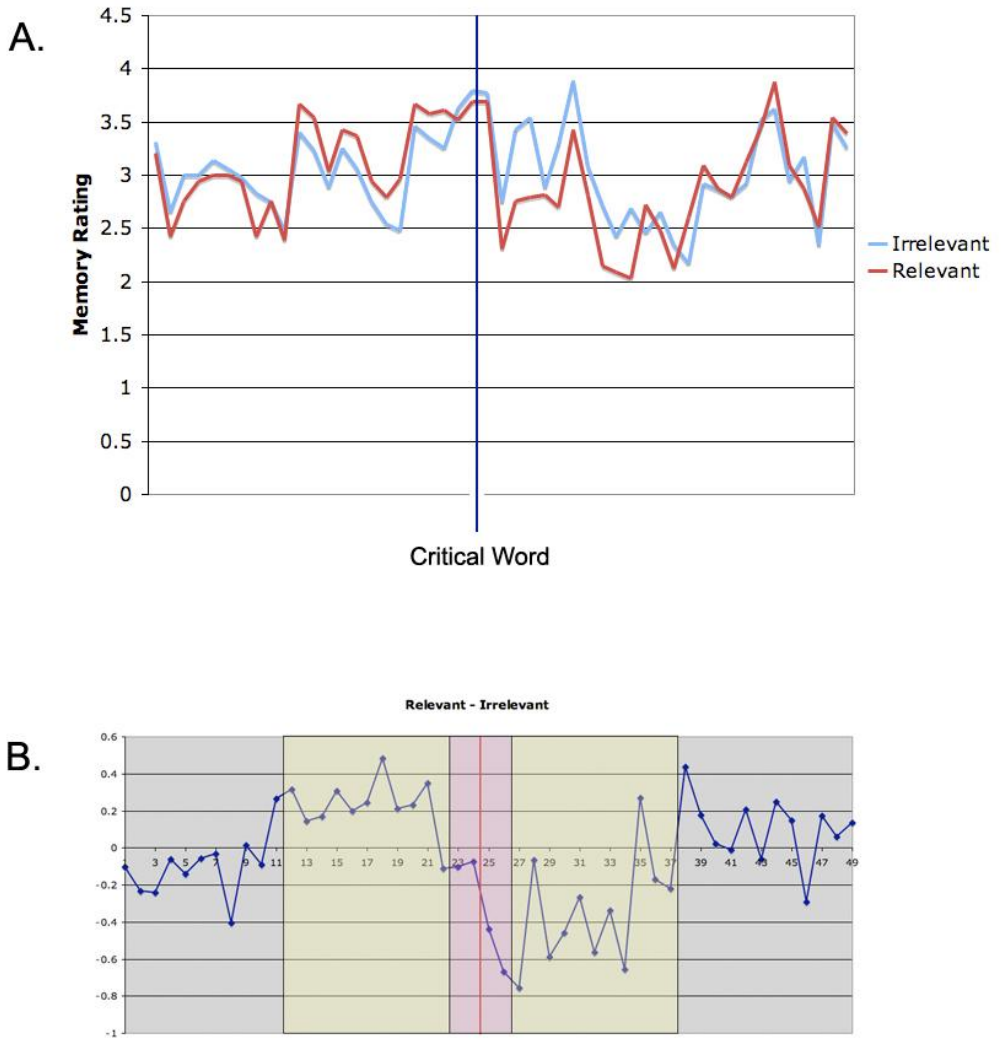

Figure 1. The x-axis in both (A) and (B) indicates the serial position of words as they appeared in the passage about Jack. In (A), memory accuracy for words are graphed separately for the Relevant and Irrelevant conditions. The second graph (B) shows the difference in accuracy between the two conditions: where the curve dips below zero, memory was worse in the Relevant than in the Irrelevant condition. Where it rises above zero, memory was better in the Relevant condition. In graph (B), the colored sections represent the clusters that were averaged and that served as the basis for statistical tests.

of words 39-50 in the relevant condition (M = 3.10, SD = .41) was higher than those in the irrelevant condition (M = 3.00, SD = .39), but this difference was not significant, t (66) = 1.07, p = .29. Figure 1a shows the average memory accuracies of words in the Relevant and Irrelevant conditions separately, and Figure 1b shows – for each word's serial position – the degree to which accuracy was higher in the Relevant than in the Irrelevant condition.

In addition, to confirm that it was the presence of the word "tennis" in the relevant condition that caused the differences between the two groups (rather than the word "singing" in the irrelevant condition), we assessed whether memory performance fluctuated more in the relevant condition than in the irrelevant condition. For each participant, we took the average accuracy of the word clusters described above, and then calculated the standard deviation across those accuracies. In the relevant condition the average standard deviation across these accuracies was .64 (SD = .22), which was significantly higher than in the irrelevant condition it was .52 (SD = .18), t (66) = 2.42, p = .02. Thus, this showed that the difference in performance between the relevant and irrelevant conditions likely stemmed from fluctuations due to the impact of the task-relevant word because performance in the irrelevant condition remained relatively stable.

Chapter 4

DISCUSSION

From the overwhelming amount of information around us, we are always selecting subsets that can be handled by our capacity-limited cognitive systems. Although it might be assumed that processing of non-prioritized information always suffers, visual cognition studies have shown that prioritization of given stimuli can sometimes enhance the processing of nearby, non-prioritized information, at least in certain conditions.

In our study, there was a significant difference in the average bet wagered by participants in the Relevant and the Irrelevant conditions, suggesting that participants in the Relevant condition took into account the critical task-relevant word “tennis”. That is, consistent with the fact that Jack excelled at tennis, participants in the Relevant condition had more positive attitudes toward Jack’s tennis playing compared to those in the Irrelevant condition.

After the voluntary prioritization of non-visual information, results showed two kinds of consequences. Before deciding how much to bet for or against Jack, participants were instructed to pay attention to all items. However, only the word

"tennis" was Relevant to their decision, and its presence or absence affected participants' memory for the words that came before or after it in the passage. When the word "tennis" appeared, participants' processing of immediately following words was worse than when that word was replaced by the word "singing", which was irrelevant to their decision. In contrast, when the word "tennis" appeared, participants were actually *better* at remembering words that came before it.

The impairment to memory for words that appeared after the critical word in the Relevant condition makes sense: it seems likely that upon hearing the word, participants became busy deciding about their bet, thus decreasing processing of words that were presented during that time. However, the retroactive enhancement of words that came before the critical word in the Relevant condition is more mysterious. Based on previous cognition studies, there are at least two possible explanations for this retroactive effect. First, in grabbing participants' attention, the word "tennis" might also have caused a burst of physiological arousal, which in turn strengthened the process of memory consolidation for items that came beforehand. Previous research has shown that the presentation of emotional pictures enhances memory for items that preceded them, relative to words that preceded neutral items (Anderson, Wais, & Gabrieli, 2006). It may be that the attention-grabbing nature of

the task-relevant word “tennis” had the same effect. A competing explanation, however, might have to do with something called “retroactive interference”. (Postman & Underwood, 1973). This refers to the way that memory of recently presented information tends to interfere with memory of information coming before. It may be that in our study, by decreasing the processing of words that came after it, the task-relevant word actually led to a release from retroactive interference. That is, because the word “tennis” caused people to process subsequent words less, these subsequent words caused less retroactive interference on the earlier words, thus leading people in the Relevant condition to have better memory for these earlier words than people in the Irrelevant condition.

By themselves, our results do not allow us to determine which of these explanations of the retroactive enhancement is accurate, and future studies are needed. For example, if we move the task-relevant word to the end, what will happen? The “retroactive enhancement” explanation will predict that the prioritization of the task-relevant word will still enhance the memory of preceding messages because of its attention-grabbing nature and the burst of physiological arousal it might cause. However, the “retroactive interference” explanation will predict that the prioritization of the task-relevant word will not enhance the memory of preceding messages

because there is going to be no impairment of subsequent messages.

Although more evidence is needed to determine the most accurate explanation for our results, the data have implications for the design of effective messages. For example, if an advertiser needs to present both positive and negative information about his or her product but wants people to remember only the positive information, it might be effective to locate the positive information before the most attention capturing message rather than after it, and the negative information right after the attention capturing part of the message.

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APPENDIX A

AUDITORY STUDY MESSAGE

Underlined words were tested words.

First part (heard by all participants)

"Jack was born in 1984, the only son in a family with eight children. His father held several jobs, including stints as a 1) mechanic, 2) painter, 3) landscaper, and 4) salesman. His mother held jobs as a 5) waitress, 6)store clerk, 7) teacher, and 8) bartender. The family moved many times during Jack's childhood, from 9) Kansas to 10) Wyoming to 11) Missouri, so Jack never felt like he could settle down. When Jack was little, his favorite foods were 12) peanuts, 13) grapes, 14) raspberries, and 15) French fries. He tried to leaning several musical instruments, including the 16) guitar, 17) trumpet, 18) violin, and 19) drums. In high school, his 20) algebra and 21) history teachers were his favorite teachers, but he couldn't stand his 22) English and 23) geometry teachers."

Critical sentence (heard by participants in Relevant condition)

"In college, Jack found that he excelled so much at 24) debating, 25) chess, *tennis*, 26) acting, and 27) journalism that many people claimed he was better at each of these things than anyone else they had ever known."

Critical sentence (heard by participants in irrelevant condition)

"In college, Jack found that he excelled so much at 24) debating, 25) chess, *singing*, 26) acting, and 27) journalism that many people claimed he was better at each of these things than anyone else they had ever known."

Concluding part (heard by all participants)

"As it turned out, after college he just kept getting better and better at each of these things, and every one who knew him considered him the best at them.Until his senior year, Jack had great difficulty deciding on a career path. He considered 28) architecture, 29) web-design, and 30) law, but ultimately decided to try his hand at 31) accounting. Despite his relative youth, he picked up a small number of loyal clients. These included small businesses specializing in 32) soap, 33) tee shirts, 34) candles, and 35) ties. With the money he made, Jack took a year-long

vacation, backpacking across 36) Uruguay, 37) Cambodia, 38) Kenya, and 39) Argentina. When he was 23, Jack met the girl who would later become his wife. When he would later look back on the moment they met, he could never remember whether it was at the local 40) Laundromat, 41) bookstore, or 42) library. When they moved in together, they traded in his old 43) Chevy Camaro and her old 44) Buick Skylark in order to purchase a new 45) Toyota Camry. In their small house, they kept two 46) dogs, some 47) goldfish, and a 48) ferret. He wants to get married in a 49) country club, but she wants to get married on a 50) beach."

APPENDIX B

QUESTIONNAIRE

Subject #: _____ Condition: _____ Date: _____

Follow-Up Questions

Jack is playing in the first round of a regional tennis tournament, and you will be placing a bet on his game. Circle one of the options below to indicate how much you would either bet on or bet against Jack's winning the game. Remember, if you're right, the more you bet, the more you win. On the other hand, if you're wrong, the more you bet, the more you lose:

$500 *against* Jack	$100 *against* Jack	$20 *against* Jack	$20 *favoring* Jack	$100 *favoring* Jack	$500 *favoring* Jack

Note: "Against Jack" means you think Jack will lose. "Favoring Jack" means you think he will win.

Please turn to next page.

Now for something a little different. For each of the following words, please indicate whether or not you heard it during the passage about Jack by circling one of the options.

		Definitey not	Probably not	Probably heard	Definitely heard
1	janitor	1	2	3	4
2	banking	1	2	3	4
3	geometry	1	2	3	4
4	dogs	1	2	3	4
5	ice cream	1	2	3	4
6	peanuts	1	2	3	4
7	paper	1	2	3	4
8	store clerk	1	2	3	4
9	Ford Taurus	1	2	3	4
10	goldfish	1	2	3	4
11	flute	1	2	3	4
12	French fries	1	2	3	4
13	country club	1	2	3	4
14	Buick Skylark	1	2	3	4
15	ties	1	2	3	4
16	Virginia	1	2	3	4
17	biology	1	2	3	4
18	Wyoming	1	2	3	4
19	shoes	1	2	3	4
20	bartender	1	2	3	4
21	Toyota Camry	1	2	3	4
22	candles	1	2	3	4
23	swimming	1	2	3	4
24	diner	1	2	3	4
25	piano	1	2	3	4

		Definitey not	Probably not	Probably heard	Definitely heard
26	library	1	2	3	4
27	grapes	1	2	3	4
28	history	1	2	3	4
29	algebra	1	2	3	4
30	debating	1	2	3	4
31	bookstore	1	2	3	4
32	ferret	1	2	3	4
33	church	1	2	3	4
34	Kentucky	1	2	3	4
35	calculus	1	2	3	4
36	tee shirts	1	2	3	4
37	parakeet	1	2	3	4
38	law	1	2	3	4
39	Nissan Sentra	1	2	3	4
40	web-design	1	2	3	4
41	apples	1	2	3	4
42	landscaper	1	2	3	4
43	Cambodia	1	2	3	4
44	drums	1	2	3	4
45	Vietnam	1	2	3	4
46	Chevy Camaro	1	2	3	4
47	chess	1	2	3	4
48	Kansas	1	2	3	4
49	journalism	1	2	3	4
50	medicine	1	2	3	4
51	teacher	1	2	3	4
52	Missouri	1	2	3	4

		Definitey not	Probably not	Probably heard	Definitely heard
53	mechanic	1	2	3	4
54	raspberries	1	2	3	4
55	nurse	1	2	3	4
56	laundromat	1	2	3	4
57	violin	1	2	3	4
58	English	1	2	3	4
59	photography	1	2	3	4
60	salesman	1	2	3	4
61	Argentina	1	2	3	4
62	guitar	1	2	3	4
63	trumpet	1	2	3	4
64	accounting	1	2	3	4
65	beach	1	2	3	4
66	Uruguay	1	2	3	4
67	winery	1	2	3	4
68	soap	1	2	3	4
69	waitress	1	2	3	4
70	Panama	1	2	3	4
71	cats	1	2	3	4
72	painter	1	2	3	4
73	secretary	1	2	3	4
74	acting	1	2	3	4
75	architecture	1	2	3	4
76	Kenya	1	2	3	4
77	mailman	1	2	3	4