

# ŁÓDŹ

## STUDIES IN LANGUAGE

Edited by  
Barbara Lewandowska-Tomaszczyk

25

Krzysztof Kosecki / Janusz Badio (eds.)

### Cognitive Processes in Language



PETER LANG  
Internationaler Verlag der Wissenschaften

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Edited by  
Barbara Lewandowska-Tomaszczyk

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## **Preface**

The present volume contains 22 papers divided into six sections. The first section concentrates on mental strategies and memory, and the two papers explore the problems related to reading and verbal memory. The next section deals with cognitive syntax and semantics, and the papers analyze verbal constructions, complementation patterns, semantic roles, modality, negation, and aspects of non-verbal communication. The third section focuses on linguistic segmentation, construal of meaning, gestures and signed languages. The two papers in Section 4 explore aspects of linguistic categorization. Section 5 discusses language acquisition and selected language disorders. The last section presents applications of cognitive linguistics to the study of literary texts. We hope that the volume will be of interest and use to a wide spectrum of readers, including students and teachers of language, linguists, translators, and researchers studying language and cognition.



Part one:

## **MENTAL STRATEGIES AND MEMORY**



# Differential Mental Strategies and Reading Patterns for Demographic Surveys: Question Organization and its Impact on Response Strategy<sup>1</sup>

*Kathleen T. Ashenfelter*

*U.S. Census Bureau, Human Factors and Usability Research Group, USA*

**Abstract:** This study investigated the possible reasons why a sharp drop occurred in the unweighted sample number of households (from about 6,000 to 2,500) between the 2007 and 2008 ACS data where the sex of the spouse was the same as the householder. An examination of a sample of households where the sex of the householder and the spouse was reported to be the same in 2007 compared to 2008 indicated that the majority of the decline (over 75%) occurred in households where the sex of one respondent was possibly mismarked, as judged by an examination of their first names and the box that was marked for their sex. The results showed that participants tended to use many different patterns or strategies when completing the 2007 ACS form while all of the participants who completed the 2008 form used the same basic strategy. Additionally, although participants tended to look at the gender item for longer periods of time with the 2008 form for the Person 1 and Person 2, the difference was not significant. Because of the unusual sequences of eye movements for participants completing the 2007 form, it is possible that this change in layout contributed to the errors or nonresponse while completing the sex question.

**Keywords:** usability testing, exploratory survey research, U.S. Census Bureau, American Community Survey, eye tracking, same-sex households, response strategy, survey form design, survey question formatting, item non-response

## 1. Introduction

The American Community Survey (ACS) is an ongoing survey that collects data that used to be gathered from the long form of the U.S. decennial Census. While the decennial United States Census counts people, the ACS collects characteristics about people over time. While everyone living or staying in the United States is required to fill out the decennial Census form, the ACS takes a nationwide sample every month. The annual sample size is approximately 3

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1 This report is released to inform interested parties of (ongoing) research and to encourage discussion (of work inprogress.) The views expressed are those of the authors and not necessarily those of the U.S. Census Bureau.

million housing units in the U.S. (250,000 per month).

This study investigated the possible reasons why a sharp drop occurred in the unweighted sample number of households (from about 6,000 to 2,500) between the 2007 and 2008 ACS data where the sex of the spouse was the same as the householder. An examination of a sample of households where the sex of the householder and the spouse was reported to be the same in 2007 compared to 2008 indicated that the majority of the decline (over 75%) occurred in households where the sex of one respondent was possibly mismarked, as judged by an examination of their first names and the box that was marked for their sex.

Although the 2008 ACS data still yields considerable same-sex spouses, the drop is very problematic because of the sensitive nature of the data and the numerous demands that have been made for the Census Bureau to release this data. The sponsors examined and dismissed many possible reasons for this decline. Through the process of elimination, they determined that a possible cause for this decline was the major change in the instrument format from a grid pattern for years prior to 2007 to a sequential pattern beginning in January 2008, as the principal outstanding yet unresolved reason for this change. The current ACS format closely mimics the format of the 2010 Census, which uses a sequential format. One major relevant part of this change in design affects both the location and layout of the gender question. In the 2007 format, gender was the second item after the person's name, with the response of "male" and "female" vertically ordered adjacent to the name (grid layout). In the new 2008 format, gender is the third item after the name and relationship items, with the responses horizontally ordered (sequential layout). It is believed that both the question order and the layout may have affected responses to the gender item, facilitating the drop in the number of same-sex spouse households. Additionally, there is evidence that improvements were made to the mail form (and not to the corresponding computer-assisted telephone interview (CATI) and computer-assisted phone interview (CAPI) modes when looking at the reporting of gender (Table 1).

**Table 1.** Percent reporting to gender with no needed allocations or data assignments due to blanks or mismarks (i.e., double marks).

<b>Mode</b>	<b>2007 ACS</b>	<b>2008 ACS</b>
Mail	96.48	98.27
CATI	99.94	99.97
CAPI	99.87	99.93

The results did not change between 2007 and 2008 for CATI or CAPI; the data were collected on the same rostering page in 2007 and 2008. This exploratory

study examined specific differences in respondent gaze patterns while filling out pages 2 and 3 of the 2007 and 2008 mail surveys.

## 2. Methods

In order to study the form with the lab's current equipment (Tobii 2150, which can only analyze digital on-screen stimuli), the usability lab converted the PDF versions of the 2007 and 2008 ACS mail forms into HTML pages that could be studied using the lab's current eye-tracking equipment. Pages 2 and 3 of each of the forms were converted into a double-page layout to simulate the way that a respondent would view the mail form while answering the first few questions. Participants were given a vignette situation in which they were asked to fill out the form for themselves, a spouse, and a four-year-old child.

Participants worked on these two pages of the ACS form; the HTML interface did not allow them to proceed to complete the remainder of the survey. Figure 1 shows the 2007 version of the ACS and Figure 2 shows the 2008 version of the ACS mail form.

The figure displays two pages of the 2007 ACS 'Grid' Form. Page 2, titled 'List of Residents', includes instructions for listing household members. It features a table with columns for 'Person 1' through 'Person 5', each with fields for 'Last Name (Please print)', 'First Name', 'Sex', 'Age for census', 'Month', 'Day', 'Year of birth', and checkboxes for 'Married', 'Single', and 'Partner'. Page 3 contains sections for 'What is this person's race?' and 'What is this person's sex?'. The race section includes checkboxes for 'White', 'Black or African American', 'Hispanic or Latino', 'Asian or Pacific Islander', and 'Other'. The sex section includes checkboxes for 'Male' and 'Female'. The form is designed to be filled out for multiple residents of a household.

Figure 1. 2007 ACS 'Grid' Form



The figure displays two pages of the 2008 ACS 'Page' Form. The left page is for Person 1 and Person 2, and the right page is for Person 3 and Person 4. Each page contains a series of questions and checkboxes for demographic and household information.

**Person 1 and Person 2 (Left Page):**

- Person 1:**
  - 1. What is Person 1's name? (Last, first, middle initial) [Text box]
  - 2. How is this person related to Person 1? (Select one)
    - ☐ Spouse or partner
    - ☐ Son or daughter
    - ☐ Daughter-in-law or son-in-law
    - ☐ Sister or brother
    - ☐ Sister-in-law or brother-in-law
    - ☐ Other relative
    - ☐ Not related
  - 3. What is Person 1's sex? (Select one)
    - ☐ Male
    - ☐ Female
  - 4. What is Person 1's age? (Select one)
    - ☐ 18-24
    - ☐ 25-34
    - ☐ 35-44
    - ☐ 45-54
    - ☐ 55-64
    - ☐ 65-74
    - ☐ 75+
  - 5. What is Person 1's race? (Select one)
    - ☐ White
    - ☐ Black or African American
    - ☐ Hispanic or Latino
    - ☐ Asian or Pacific Islander
    - ☐ Other race
  - 6. What is Person 1's ethnicity? (Select one)
    - ☐ White
    - ☐ Black or African American
    - ☐ Hispanic or Latino
    - ☐ Asian or Pacific Islander
    - ☐ Other race
  - 7. What is Person 1's marital status? (Select one)
    - ☐ Married
    - ☐ Divorced
    - ☐ Widowed
    - ☐ Never married
  - 8. What is Person 1's education level? (Select one)
    - ☐ Less than high school
    - ☐ High school graduate
    - ☐ Some college
    - ☐ Bachelor's degree
    - ☐ Graduate degree
  - 9. What is Person 1's income? (Select one)
    - ☐ Less than \$10,000
    - ☐ \$10,000-\$14,999
    - ☐ \$15,000-\$24,999
    - ☐ \$25,000-\$34,999
    - ☐ \$35,000-\$49,999
    - ☐ \$50,000-\$74,999
    - ☐ \$75,000-\$99,999
    - ☐ \$100,000+
- Person 2:** (Similar questions to Person 1)

**Person 3 and Person 4 (Right Page):**

- Person 3:** (Similar questions to Person 1)
- Person 4:** (Similar questions to Person 1)

Figure 2. 2008 ACS "Page" Form

## 2.1. Participants

Participants for this testing were thirteen internal Census Bureau employees. Although none of the participants worked directly on developing the ACS mail forms, some mentioned having worked on issues related to some of the specific questions that constitute the survey. All participants volunteered their time and received no monetary compensation to participate in the study. Starting with the first participant's random assignment to the 2008 form, the participants were alternatively assigned to one of two conditions corresponding to either the 2007 or the 2008 form to ensure that equal numbers of people were assigned to each of the prototypes as the study progressed.

## 2.2. Eye-Tracking

The participants' eye movements were recorded during the usability test using a trial version of Tobii Studio Enterprise Edition (Tobii Technology Inc. 2008). The Tobii eye-tracking device monitors the participant's eye movements and records eye-gaze data. Data collected from the eye-tracking device includes eye-gaze position, timing for each data point, eye position, and areas of interest. The Tobii 2150 eye tracker records data at a rate of 50 Hz.

Areas of interest (AOIs) for the 2007 and 2008 ACS mail forms were defined prior to the usability evaluation. AOIs are typically used in eye-tracking analysis to evaluate how many times and how long participants looked at a

certain area of the screen. The AOIs most pertinent to the current study are Person 1, Person 2, and Person 3. The unit of measurement for a digital display on the Tobii system software and hardware is one pixel, and AOIs are defined by their X and Y pixel coordinates on the 1024 by 768-pixel screen.

### **3. Results**

Analysis of the eye-tracking results was performed using a trial version of Tobii Studio Enterprise software (Tobii Technology Inc. 2008) and Matlab (The Mathworks 2007). Although statistical analyses were performed in order to compare participant performance between the two versions of the ACS mail form, the reader should keep in mind that the number of participants was small ( $n = 13$ ) and that the participants were not randomly sampled from a population, nor were they randomly assigned to condition.

Overall, the participants who interacted with the 2007 ACS form showed much more variability in their strategy for filling out the form. Most participants did not fill out the questions on the 2007 form by following the numbered sections horizontally across pages 2 and 3 for Person X before moving on to Person X+1. Further, several participants who saw the 2007 form stated that they were not sure they were finished with this section of the survey. They proceeded to look around the form before deciding they had provided all of the information necessary for their assigned three-person household. None of the participants who saw the 2008 form made such a statement.

#### **3.1. Differences in Visualization and Survey-Taking Strategy**

In order to examine overall movement patterns, the scan-path pattern of the participants' gaze data were analyzed. The gaze plots displayed in this section include numbered circles that represent the places that participants looked on the screen (for at least 100 milliseconds) in temporal sequential order. The time stamp for the duration of the gaze events depicted in the image can be found in the legend at the bottom-left corner of the image.

All of the participants who saw the 2008 ACS mail form completed the items in the same overall pattern: all items for Person 1, then all items for Person 2, then all items for Person 3. In the gaze path plots below, either the entire session is shown or a specific segment was selected for legibility's sake to illustrate the participant's eyes moving to the Person 2 items after completing all of the items for Person 1. Eye-gaze data from three participants are displayed as examples.

Figure 3 shows the first one minute and fourteen seconds of gaze path information for Participant 1, who saw the 2008 survey. This plot illustrates that

the participant completed Person 1, and then moved on to Person 2. The data from the remainder of the session are omitted in order to preserve the legibility of this plot.

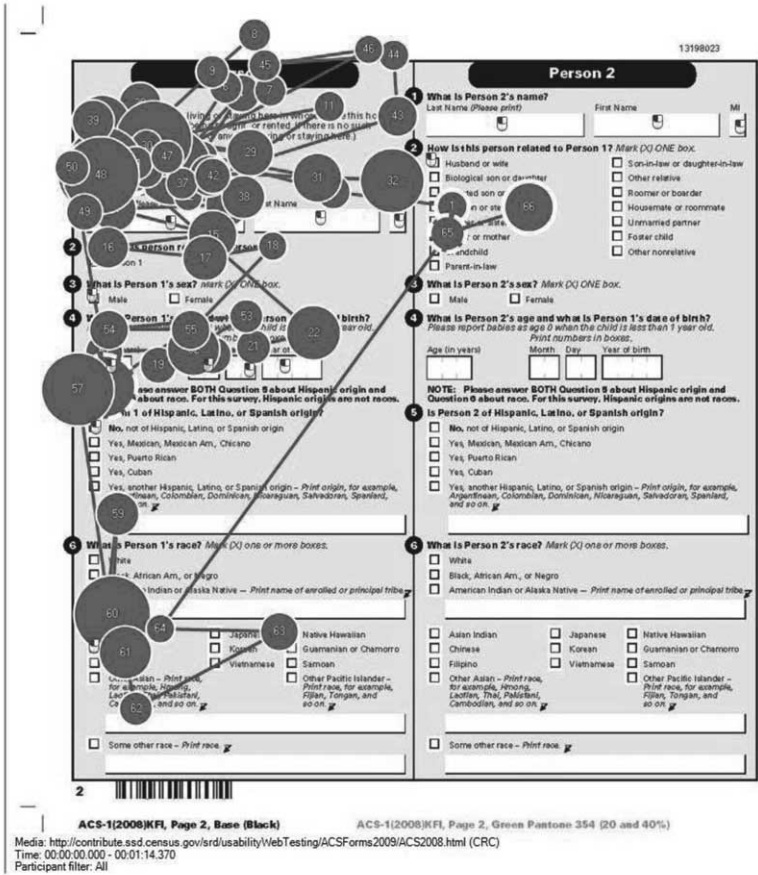


Figure 3. Gaze Plot for Participant 1: 2008 Survey

Participant 3 and 5 also completed Person 1, and then moved on to Person 2.

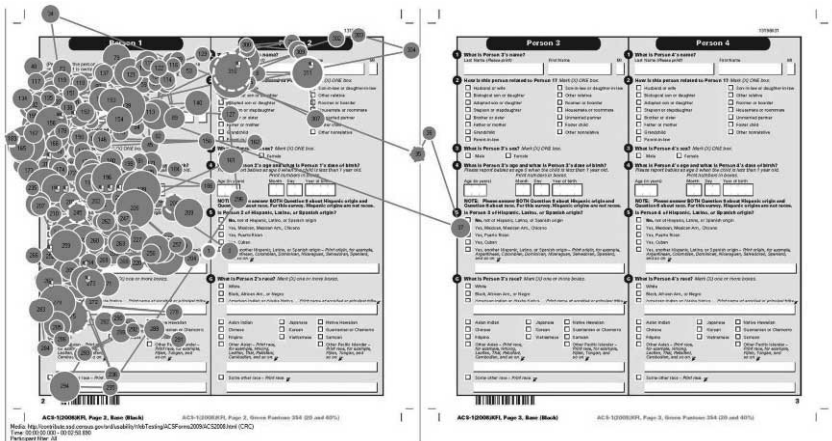


Figure 4. Gaze Plot for Participant 3: 2008 Survey

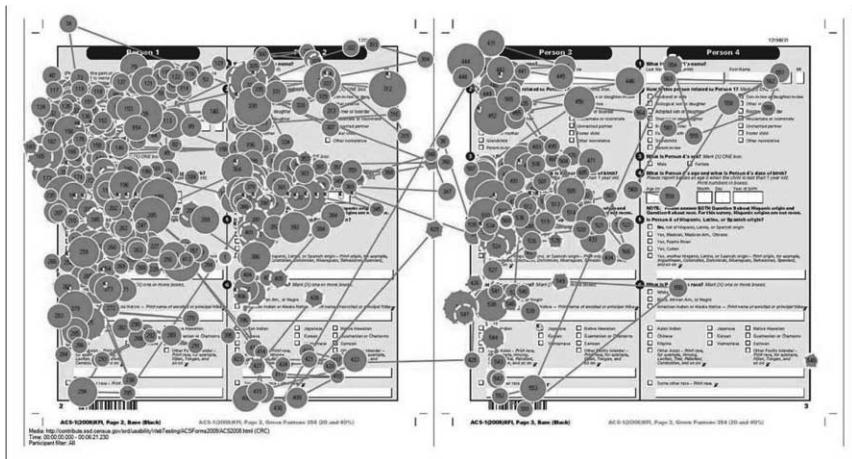


Figure 5. Gaze Plot for Participant 5: 2008 Survey

In contrast to the consistent manner in which participants completed the 2008 ACS mail form, there were five different survey-taking patterns utilized by the six participants who completed the 2007 ACS mail form. Table 2 describes these patterns in general terms. The participant number of the person who exhibited each pattern is given in parentheses after the pattern title. Eye gaze

data from three participants are provided as examples to aid in the interpretation of Table 2.

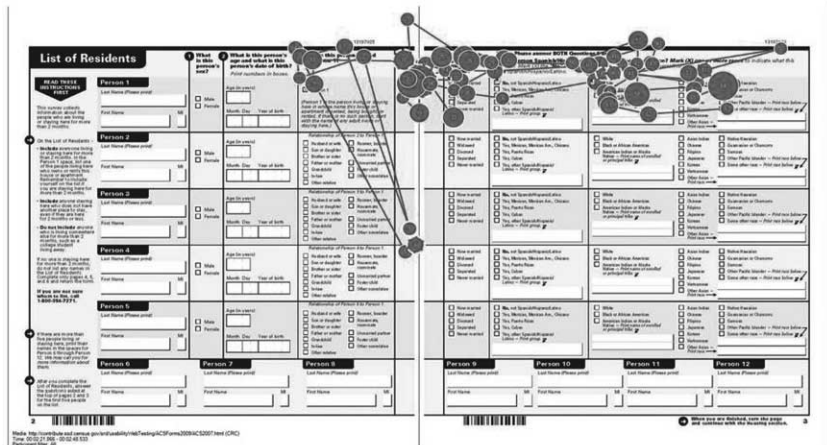
**Table 2.** Patterns of Survey–Taking Eye–Gaze Behavior for the 2007 ACS Mail Form

Pattern	Order Items were Completed
Pattern 1 (P10)	1) All items for Person 1 completed horizontally across Pages 2 and 3 2) All items for Person 2 completed horizontally across Pages 2 and 3 3) All items for Person 3 completed horizontally across Pages 2 and 3
Pattern 2 (P12)	1) All items for Person 1 completed horizontally across Page 2 2) All items for Person 2 completed horizontally across Page 2 3) All items for Person 3 completed horizontally across Page 2 4) All items for Person 1 completed horizontally across Page 3 5) All items for Person 2 completed horizontally across Page 3 6) All items for Person 3 completed horizontally across Page 3
Pattern 3 (P2, P8)	1) Name items for Persons 1, 2, and 3 completed vertically down Page 2 2) Sex items for Persons 1, 2, and 3 completed vertically down Page 2 3) Relationship items for Persons 1, 2, and 3 completed vertically down Page 2 4) Marital Status items for Persons 1, 2, and 3 completed vertically down Page 3 5) Hispanic origin items for Persons 1, 2, and 3 completed vertically down Page 3 6) Race items for Persons 1, 2, and 3 completed vertically down Page 3
Pattern 4 (P4)	1) Name items for Persons 1, 2, and 3 completed vertically down Page 2 2) Sex items for Persons 1, 2, and 3 completed vertically down Page 2 3) Relationship items for Persons 1, 2, and 3 completed vertically down Page 2 4) All items for Person 1 completed horizontally across Page 3 5) All items for Person 2 completed horizontally across Page 3 6) All items for Person 3 completed horizontally across Page 3
Pattern 5 (P6)	1) All items for Person 1 completed horizontally across Page 2 2) All items for Person 2 completed horizontally across Page 2 3) All items for Person 1 completed horizontally across Page 3 4) All items for Person 2 completed horizontally across Page 3 5) All items for Person 3 completed horizontally across Pages 2 and 3

Participant 6 used Pattern 5 to complete the survey. The following four figures illustrate this process. This person first looked around the pages, then read the instructions, then completed all of the questions for Person 1 horizontally and

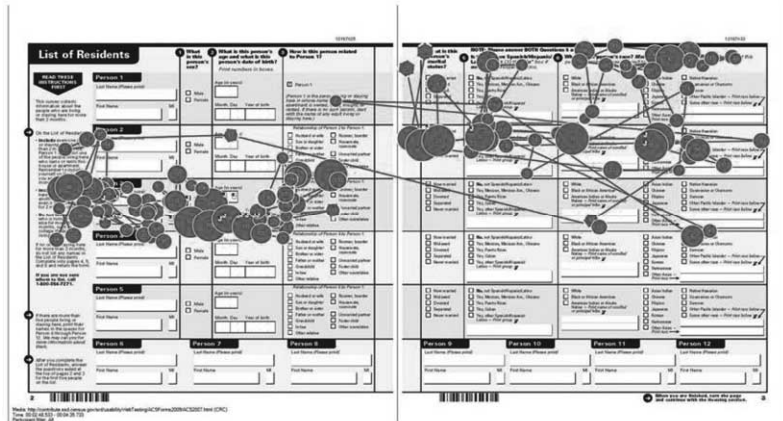
[illegible]

Next, the participant horizontally completed the items for Person 1 on Page 3.



**Figure 7.** Gaze Plot 2 for Participant 6: 2007 Survey

Then, the participant demonstrated evidence of confusion. Specifically, the participant finished the items for Person 2 horizontally on Page 3 before looking at the items for Person 3 on Page 3. The participant then looked back at the name item for Person 3 on Page 2. Next, the participant looked at the left navigation instructions before filling out the items for Person 3 on Page 2 horizontally and sequentially.



**Figure 8.** Gaze Plot 3 for Participant 6: 2007 Survey

Finally, the participant finished the items for Person 3 on Page 3 in horizontal order, but with repeated glances to the instructions at the top of Page 3. They look again at the left navigation instructions on Page 2 and then around the page before finishing.

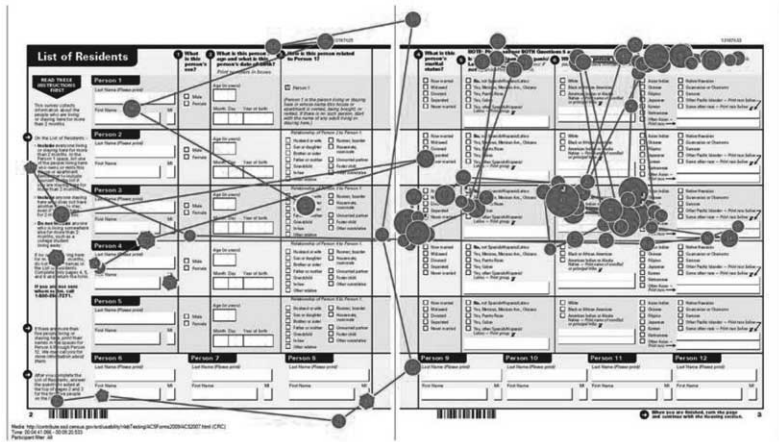


Figure 9. Gaze Plot 4 for Participant 6: 2007 Survey

Participant 8 showed Pattern 3 for completing the survey and started the name item for Person 1, then read the left navigation instructions before completing the rest of the survey items.

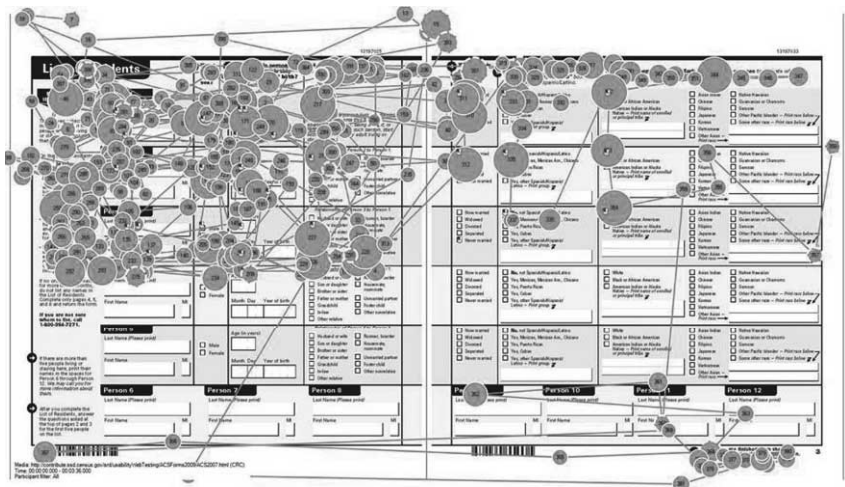
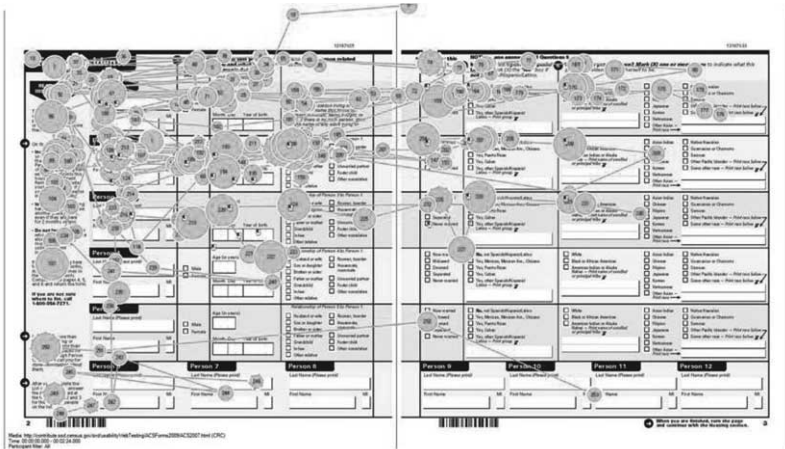


Figure 10. Gaze Plot for Participant 8: 2007 Survey



Participant 10 filled out the form using Pattern 1, which was in the horizontal item order (in horizontal, sequential order across Pages 2 and 3 for each person, consistent with the numbered instructions at the top of the pages).



**Figure 11.** Gaze Plot for Participant 10: 2007 Survey

### 3.2. Overlooked Items

While all of the participants for both the 2007 and 2008 forms either mentioned aloud how they would answer the gender item and/or clicked on the item with the mouse, not all of them answered this item immediately after completing the first item. There is also some evidence that suggests that even when participants answer this question, they do not necessarily pay active attention to this question or look at it for very long. For example, one participant mentioned that he would select “female” as the answer to this question for Person 2, but he did not gaze at the box containing this question (e.g., Area of Interest “Person 2 Sex”) nor did he make a complete mouse click on it. The usability contact recommends further testing using the paper questionnaire and the X120 eye tracker to investigate this issue.

**Table 3.** Fixation Duration (Seconds) on the Gender Item for the 2007 ACS Mail Form  
2007 Form

Participant	Person 1 Sex	Person 2 Sex	Person 3 Sex
P2	2.85	1.10	0.00
P4	1.73	1.40	6.86
P6	3.29	0.12	11.02
P8	3.19	3.45	5.37
P10	1.44	5.00	3.59
P12	2.82	1.67	0.18
Average	2.55	2.12	4.50
Std. Dev	0.78	1.80	4.20

**Table 4.** Fixation Duration (Seconds) on the Gender Item for the 2008 ACS Mail Form  
2008 Form

Participant	Person 1 Sex	Person 2 Sex	Person 3 Sex
P1	0.00	3.05	2.33
P3	10.22	3.03	3.36
P5	5.04	6.32	7.50
P7	3.07	1.85	2.35
P11	4.01	0.00	0.56
P13	28.49	9.93	0.00
Average	8.47	4.03	3.55
Std. Dev	10.36	3.55	2.67

Tables 3 and 4 present the average fixation duration (e.g., amount of time that a person fixated upon a specific area of the survey) in seconds for the gender item for the 2007 and 2008 survey forms. Participant 9 was dropped from this analysis because no eye-tracking data were recorded for this participant because of an equipment problem. As the tables show, participants tended to look at the gender items for longer periods of time for the 2008 form than for the 2007 form for Person 1 and Person 2. The participants tended to look at the gender item for Person 3 for longer periods of time for the 2007 form than for the 2008 form. However, these differences were not significant ( $\alpha = 0.05$ ) in an independent samples t-test for the gender item for Person 1 ( $t(10) = -1.40, p > 0.05$ ), Person 2 ( $t(10) = -1.18, p > 0.05$ ), or Person 3 ( $t(10) = 0.90, p > 0.05$ ).

These statistics may be impacted by missing data caused by participants' eye blinks and temporary equipment failure and should be considered as estimates only. This does suggest that for the 2007 form, the fixation duration on this item is generally short, which could suggest that some respondents are missing this question or could be reporting in error.

### **3.3. Duration of Survey–Taking Session**

On average, participants spent 4 minutes and 0.8 seconds on the 2007 form and 4 minutes and 3.9 seconds on completing the scenario using the 2008 form. This difference was not statistically significant ( $\alpha = 0.05$ ) in an independent samples *t*-test ( $t(11) = 0.061$ ,  $p > 0.05$ ).

## **4. Limitations and Conclusion**

As with most laboratory research, there are some scope–related limitations to this testing. First, participants were not randomly assigned to condition for this preliminary testing.

Second, the number of participants per condition is associated with low statistical power. When statistical power is insufficient, true effects may not be detected. Future rounds of testing will incorporate larger numbers of participants to increase statistical power.

Another limitation of this study was the digital mock–up of the ACS forms that was neither the true–to–life paper mail form, nor an interactive web survey. Efforts to use the most realistic ACS form as possible will be incorporated into future rounds of testing.

Finally, internal Census Bureau participants were recruited for testing in order to reduce the amount of time the recruitment process normally takes because of the sponsor’s deadline for results. Although none of these participants was associated with the actual layout design of the survey, several had worked on the questions that the ACS contains. Future testing will include recruiting participants who are not Census Bureau employees and who have not had experience working with ACS forms or questions.

This usability study showed that participants tended to use many different patterns or strategies when completing the 2007 ACS form while all of the participants who completed the 2008 form used the same basic strategy. Additionally, participants reported being more satisfied with the 2008 form overall, although there was no significant difference ( $\alpha = 0.05$ ) in the amount of time taken to complete the two different versions of the form. Additionally, although participants tended to look at the gender item for longer periods of time with the 2008 form for the Person 1 and Person 2, the difference was not significant. Because of the unusual sequences of eye movements for participants completing the 2007 form, it is possible that this change in layout contributed to the errors or nonresponse while completing the gender question. The lack of significance in the statistical testing in this study may be due to the small sample size and an associated lack of statistical power. However, there is supporting evidence that the change in design improved response rates for the gender item

on the mail form, supporting the hypothesis that the 2007 design led to frequent errors of assignment.

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