



# The Impact of Working Memory in Survey Methodology: A Look at Response Order Effects, Question Order Effects, and the Health and Retirement Study Cognitive Measures

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- ❖ Introduction
- ❖ Background
  - Cognitive psychology research on working memory
  - Response order, question order, & survey mode effects
  - Studies by Knäuper and colleagues
- ❖ Research Questions & Data Collection
- ❖ Findings
  - Response Order Effects
  - Question Order Effects
  - Comparison of Working Memory Measures to HRS
- ❖ Conclusions & Contribution
- ❖ Limitations



- ❑ Cognitive Aspects of Survey Methodology (CASM) (Jabine, Straf, Tanur, & Tourangeau, 1984; Jobe & Mingay, 1991)
  - Linking Cognitive Psychology and Survey Methodology
  
- ❑ Examine how cognitive processes impact the quality of survey responses
  
- ❑ Focus of Memory Research
  - Behavioral questions – autobiographical memory (Belli, 2013; Blair & Burton, 1987; Friedman, 1993)
  - Attitude questions
    - ❑ Stored in memory (Eagly & Chaiken, 1993)
    - ❑ Memory retrieval influenced by context resulting in attitudes constructed at the time of a response (Schwarz & Bohner, 2001; Tourangeau, 1992)
  - Minimal research on working memory



- ❖ Does working memory impact question order and response order effects?
- ❖ Is the impact of working memory on question order and response order effects consistent across two modes of survey administration, telephone and web?
- ❖ Is the impact of working memory on question order and response order effects consistent across all ages?
- ❖ How do working memory measures compare to memory measures from the Health and Retirement Study (HRS)?



# Cognitive Psychology Research on Working Memory



- ❑ What is Working Memory?
  - System involving the limited storage of relevant information and transient processing needed to perform ongoing cognitive tasks (Badeley & Hitch, 1974)
- ❑ 3 Components of Working Memory (Badeley & Hitch, 1974 ; Gathercole & Baddeley, 1993)
  - Central Executive, Phonological Loop, Visuo-spatial Sketchpad
- ❑ Activation-based pool of shared resources (Just & Carpenter, 1992)
  - As resources are used for one function, storage or processing, fewer resources are available for the other
  - Maximum capacity - if exceeded performance declines



- How is Working Memory Measured?
  - Reading/Listening/Sentence span (Daneman & Carpenter, 1980; Engle, Tuholski, Laughlin, & Conway, 1999; Freitas, Ribeiro, Radanovic, & Mansur, 2007)
  - Alphabet span (Craik, 1986; Waters & Caplan, 2003)
  - Subtract 2 span (Salthouse, 1988; Waters & Caplan, 2003)
  - Operation/Computation span (La Pointe & Engle, 1990; Salthouse & Babcock, 1991; Turner & Engle, 1989)
  
- Attention & Working Memory Lab at Georgia Tech (Engle)
  - [englelab.gattech.edu](http://englelab.gattech.edu)





- Working memory highly related to (but separate construct from)
  - **Short-term memory** (Cowan, 1988 & 1995; Conway et al., 2002)
  - **General fluid intelligence** (Ackerman, Beier, & Boyle, 2005; Conway et al., 2002; Engle et al., 1999; Kyllonen & Christal, 1990; Mogle, Lovett, Stawski, & Sliwinski, 2008; Salthouse & Pink, 2008; Unsworth & Engle, 2006)
  - **Language comprehension & processing** (Caplan & Waters, 1999; Daneman & Merikle, 1996; DeDe, Caplan, Kemtes, & Waters, 2004; Gathercole & Baddeley, 1993; Just & Carpenter, 1992)



- Working memory and aging effects
  - There are age differences in working memory (Bopp & Verhaeghen, 2005)
  - Significant negative correlation (Caplan, DeDe, Waters, Michaud, & Tripodis, 2011; Caplan & Waters, 2005)
  - Fewer resources available, reach maximum capacity earlier (Brébion, Smith, & Ulrich, 1997 ; Morris, Gick, & Craik, 1988; Norman & Bobrow, 1975; Salthouse & Babcock, 1991)
  - Decline in processing speed (Caplan et al., 2011; Caplan & Waters, 2005; Salthouse, 1994; Stine, Wingfield, & Poon, 1986)
  - More prominent on complex tasks (Babcock & Salthouse, 1990; Gick et al., 1988; Just & Carpenter, 1992; Salthouse, 1991)



# Response Order, Question Order, and Survey Mode Effects



- Order of response options impacts the response option selected  
(Schuman & Presser, 1981; Sudman et al., 1996)
  - Primacy effects – earlier items selected more often
  - Recency effects – later items selected more often
  - Impacted by amount of cognitive processing extended to response options (Krosnick & Alwin, 1987)
  - More prominent in respondents with lower cognitive ability
  - Can occur with as few as two response options (Hippler, Schwarz, & Noelle-Neumann, 1989; McClendon, 1986)



- Presence of a question impacts how respondent formulates their response on a subsequent question (Schuman & Presser, 1981; Sudman, Bradburn, & Schwarz, 1996; Tourangeau, Rips, & Rasinski, 2000)
  - Consistency (or assimilation)
    - Including information from previous question
  - Contrast
    - Excluding information from previous question.
    - Comparison-based (Sudman, Bradburn, & Schwarz, 1996)
    - Requires more cognitive effort (Sudman, Bradburn, & Schwarz, 1996; Tourangeau, Rips, & Rasinski, 2000)



- ❑ Cognitive processing – Different sensory channels (Fricker, Galesic, Tourangeau, & Yan, 2005; Schwarz, Strack, Hippler, & Bishop, 1991)
- ❑ Response Order Effects (Krosnick & Alwin, 1987; Schwarz et al., 1991)
  - Primacy more prominent in self-administered
    - ❑ Eye-tracking confirm more focus on earlier options (Galesic, Tourangeau, Couper, & Conrad, 2008)
  - Recency more prominent in interviewer-administered
    - ❑ Do not fully process early options before more options are presented
- ❑ Question order effects
  - Order of questions and speed can differ
    - ❑ Self-administered – Respondent may read questions “out of order” (Schwarz et al., 1991)
    - ❑ Interviewer typically sets faster pace than self-administered (Chang & Krosnick, 2009; Schwarz et al., 1991)



# Knäuper and Colleagues



- ❑ Complex questions regarding depressive symptoms
  - Retrospectively reported symptoms at any point during lifetime
  - Symptoms attributed to physical factors or not
- ❑ Working Memory measured with a sentence span
- ❑ Results
  - Differences in working memory between young and old
  - Low working memory respondents more likely to attribute symptoms to physical causes
  
- ❖ *Do findings generalize to simple questions of attitude?*





- Examined question order effects in three groups
  - Younger adults (ages 19-40)
  - Older adults (ages 60-100) with low working memory capacity
  - Older adults (ages 60-100) with high working memory capacity
- Effects present for younger and older/high groups
  - Attenuated for older/low
  
- ❖ *What about working memory groups for younger adults?*



- Meta-analysis of response order effects
  - Age used as a proxy for working memory
  - More prominent effects in older respondents
  - Theorized some of the effects may be attributed to differences in working memory
  
- ❖ *Need to test using direct measures of working memory.*



- ❑ Data quality impacted by interaction of question difficulty and cognitive ability
  - Data from AHEAD (Since merged with HRS)
  - Memory measures
    - ❑ Immediate recall of 10 words
    - ❑ Counting backwards from 20
    - ❑ Date, day of week, current U.S. President
    - ❑ Serial 7s task
  
- ❖ *Can results extend to working memory - are respondents classified the same (high/low) with HRS measures and working memory measures?*



# Research Questions and Data Collection



- ❖ Does working memory impact question order and response order effects?
- ❖ Is the impact of working memory on question order and response order effects consistent across two modes of survey administration, telephone and web?
- ❖ Is the impact of working memory on question order and response order effects consistent across all ages?
- ❖ How do working memory measures compare to memory measures from the Health and Retirement Study (HRS)?



- Analytical sample size  $n=601$ 
  - Telephone  $n=341$ ; Web  $n=260$
  - 3,700 Nebraska residents invited to participate
  - Randomly assigned to mode prior to contact
  
- Collected November 2016 – January 2017



- ❑ Preferences for:
  - Books, Movies, Performances, Music, Sports, & Attractions
  
- ❑ Six versions to “randomize” response options
  - Three questions with 2 response options (order rotated on even/odd versions)
  - Three questions with 6 response options (Latin square design used to counterbalance options)

Of the following, which type of book do you prefer to read?  
Fiction, or  
Non-fiction



- ❑ 3 Pairs of related questions, presentation order rotated on even/odd versions
  - Happiness: overall / with intimate partner
  - Labor conditions: workers have right to strike / businessmen have right to shut down
  - Legal abortion: married woman who doesn't want more children / chance baby has serious birth defect





- ❑ Sentence span
  - A clock is used to tell time
  - Grass is the color blue
  - Birds fly in the sky
  
- ❑ Alphabet span
  - Home
  - Wife
  - Flag
  
- ❑ Set of 3 and 5 for both measures



- All-or-nothing unit scoring
  - 1 point for every correct word recalled
  - Max score 16

	Overall	Telephone	Web
Mean	12.5	11.4	13.9
Range	1-16	1-16	8-16

- Web scores significantly higher than telephone scores
  - $t=12.81, p<.0001$
- Used z-scores calculated within each mode
  - Telephone raw score of 12,  $z=0.2097$
  - Web raw score of 12,  $z=-0.9488$ .



- Serial 7's
  - What is 7 subtracted from 100?
  - 5 iterations (93, 86, 79, 72, 65)
- Who is the Vice President of the United States right now?
  - Biden/Pence
- Immediately recall 10 words
  - HRS List 1

	Overall	Telephone	Web
Mean	11.1	10.4	11.9
Range	1-16	1-16	1-16

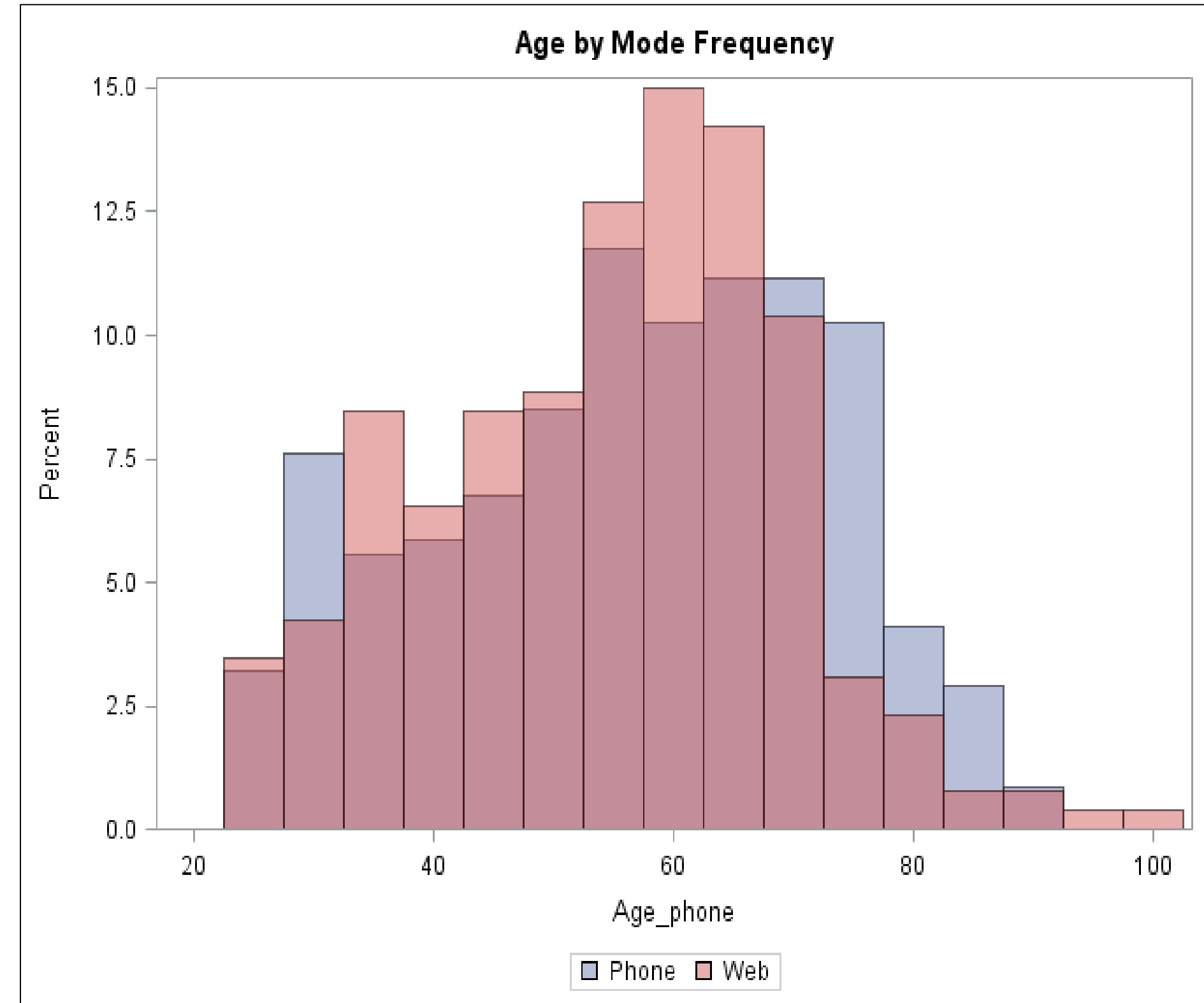


- Respondent Age (continuous)

- Range 24-98

Overall	Telephone	Web
55.7	56.6	54.5

- Telephone respondents slightly older  
 $t=1.70, p=.09$





# Response Order Effects



- Respondents with lower working memory are more susceptible to primacy and recency effects
  - As working memory improves, respondents will be less likely to:
    - Select a late response in telephone
    - Select an early response in web



- Multilevel logistic regression
  - Combined 3 questions with 2 responses
  - Combined 3 questions with 6 responses
  - Predicting the response option location (ie. 1<sup>st</sup>/2<sup>nd</sup>, early/late)
  - Account for repeated measures
  - Control for question and education
  - Predictors: Age, Working Memory, Mode, & all interactions

*logit* [ $P(\text{location} = 1)$ ] =

$$\beta_{00} + \beta_{10} \text{Question} + \beta_{01} \text{Education} + \beta_{02} \text{Age} + \beta_{03} \text{WM} + \beta_{04} \text{Mode} + \beta_{05} \text{Age} * \text{WM} + \beta_{06} \text{Age} * \text{Mode} + \beta_{07} \text{WM} * \text{Mode} + \beta_{08} \text{Age} * \text{WM} * \text{Mode} + V_j + U_{ij}$$

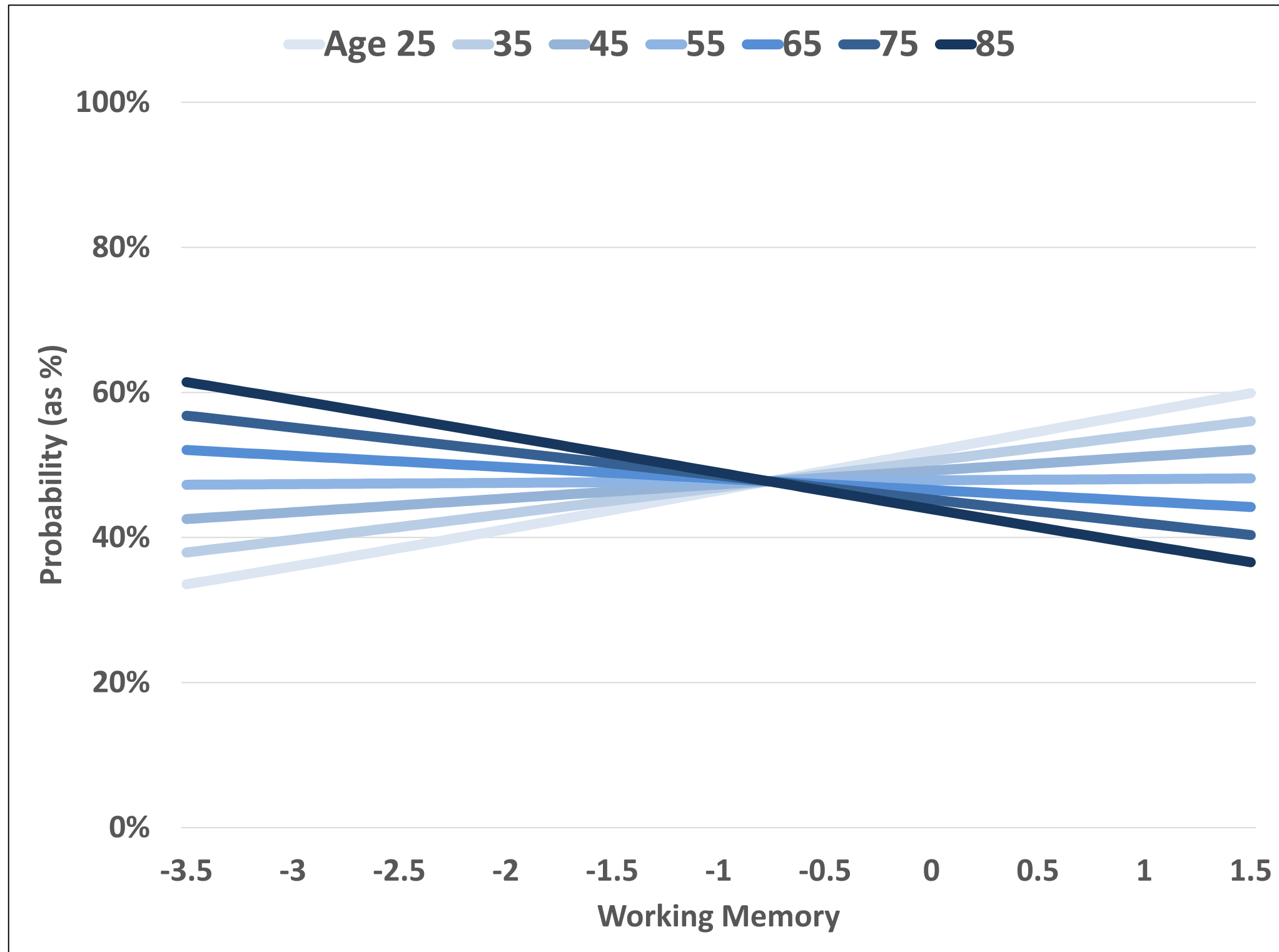
where  $V_j \sim N(0, \sigma_v^2)$  and  $U_{ij} \sim N(0, \sigma_u^2)$

# Probability of Selecting the First Response Option (Across Q1-Q3) – Combined Modes

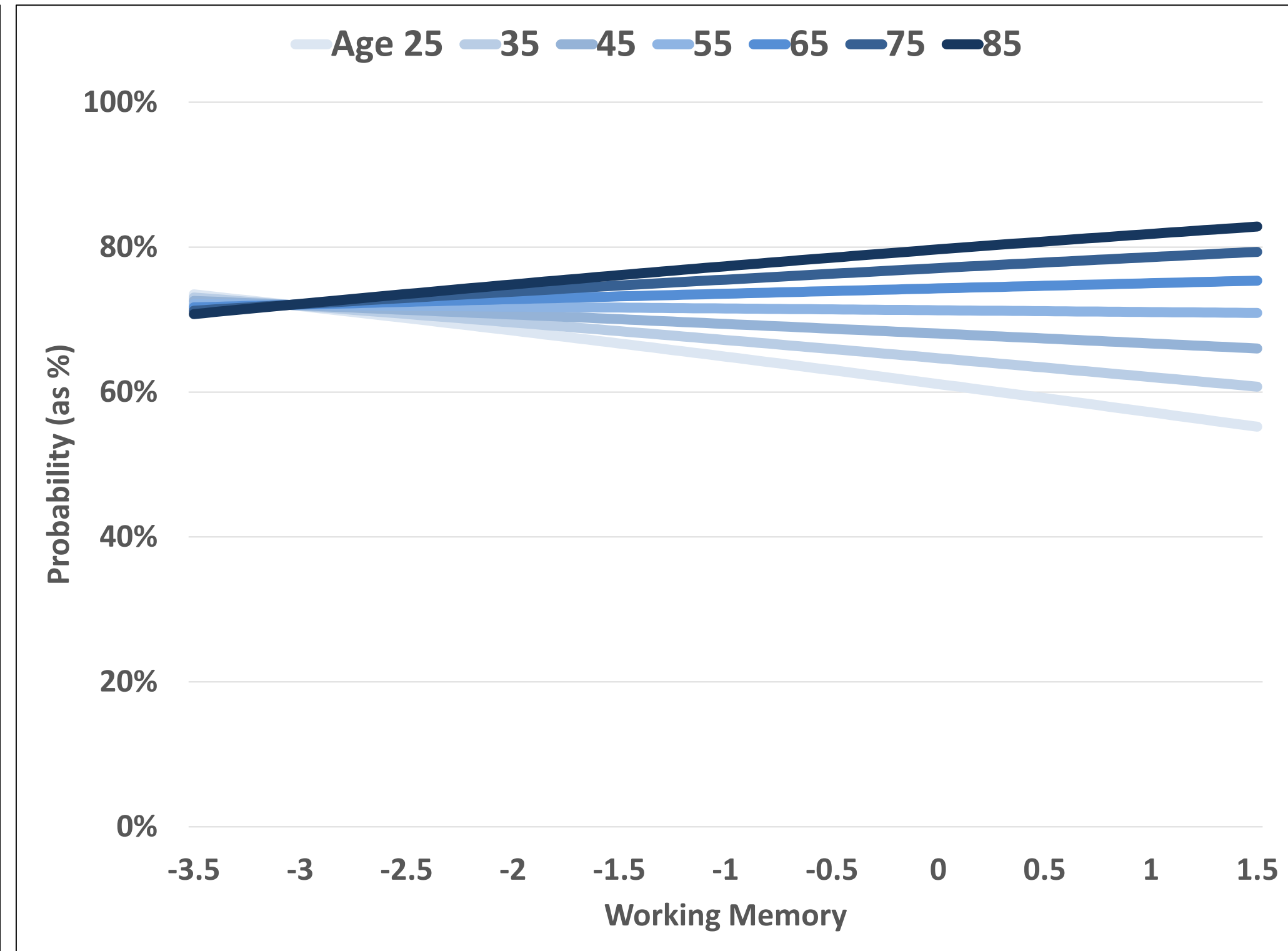


Mode (p<.01), Age\*Mode (p<.01), Age\*WM\*Mode (p<.10)

## Telephone



## Web



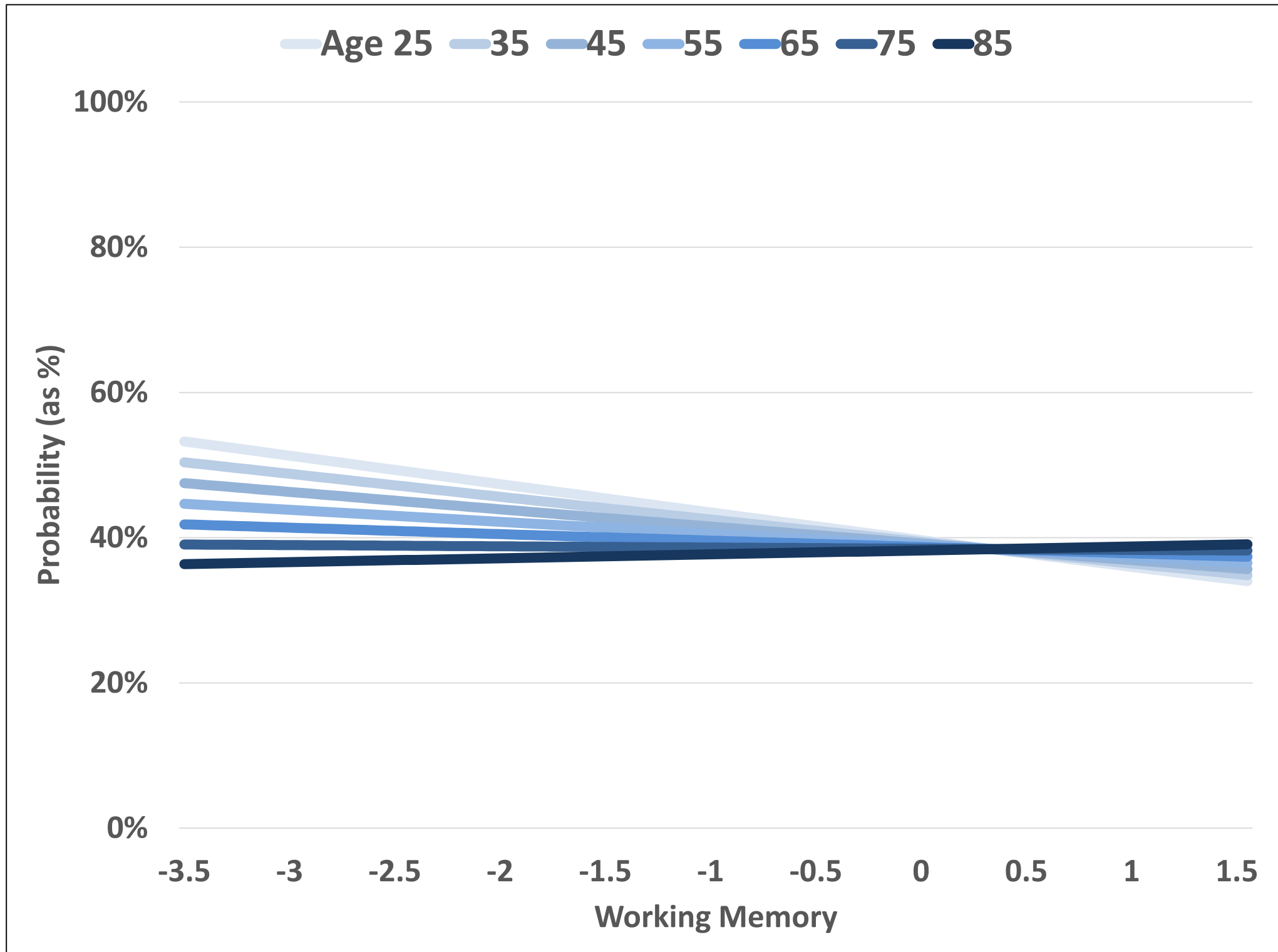


# Probability of Selecting a Late Response Option (Across Q4-Q6) – Combined Modes

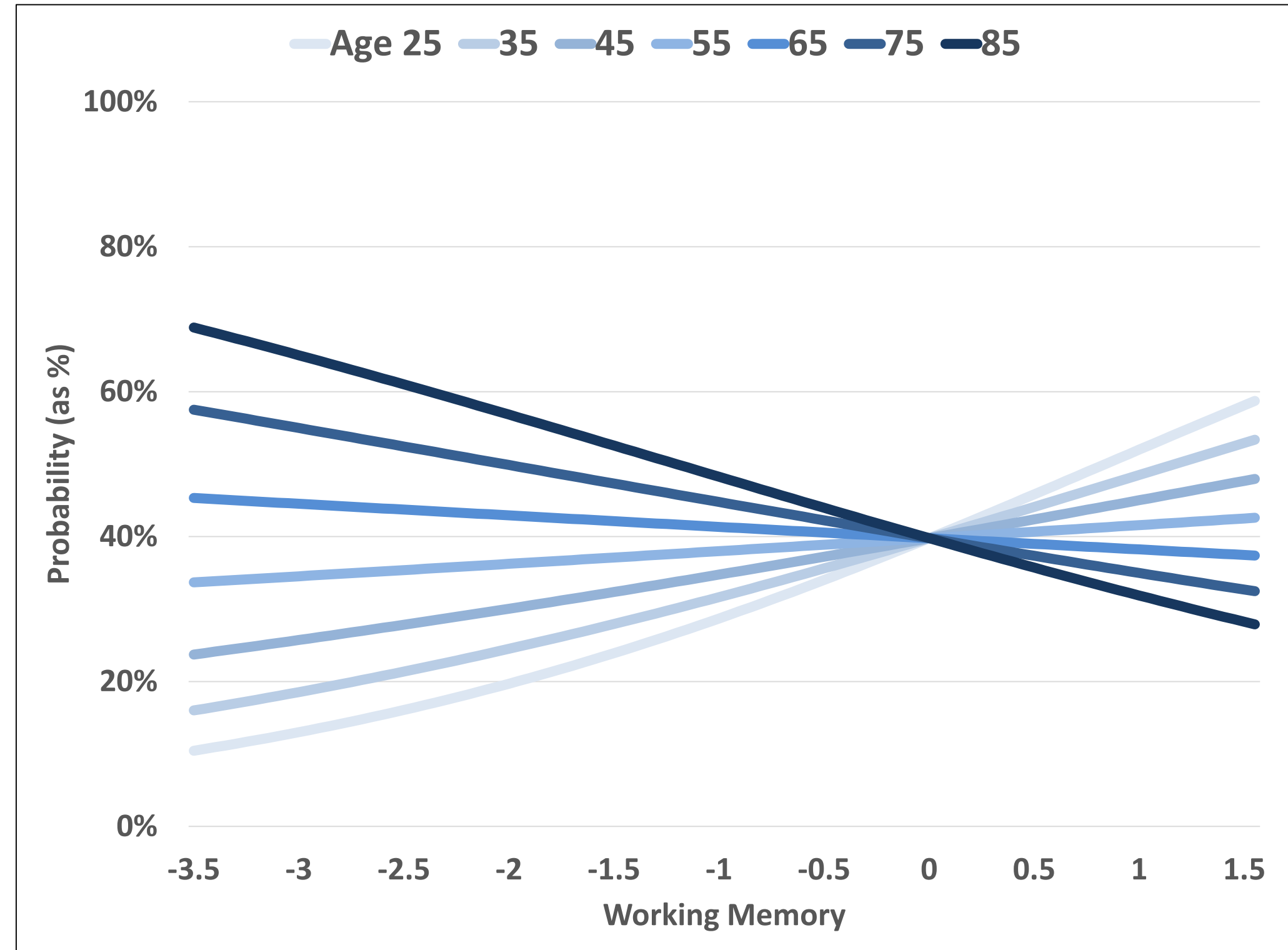


WM\*Mode (p<.05),  
Age\*WM\*Mode (p<.05)

## Telephone



## Web





- ❑ Working memory appears to influence respondents' response option selection
- ❑ Significant interactions
  - 2 Response options: Age\*Mode, Age\*WM\*Mode
  - 6 Response options: Age\*WM, Age\*WM\*Mode
- ❑ A higher working memory only “helps” respondents <65
  - Adverse effect for the older respondents
- ❑ Effects are not consistent for both modes



# Question Order Effects



- Respondents with higher working memory are more likely to be influenced by the previous question.
  - There will be a significant interaction between working memory and the answer to the first of two related questions.
  
- Part-whole questions: expect a contrast effect among higher working memory respondents when the part question is asked first. (Schuman & Presser, 1981)



- Logistic regression
  - 3 pairs of related questions, pairs analyzed separately
  - Predicting the selection of “Very happy” or “Yes”
  - Control for education
  - Predictors: Age, Working Memory, Response to Previous Question, & all interaction

$$\begin{aligned} \text{logit} [P(\text{Response} = \text{"VERY HAPPY"/"YES"})] = & \\ & \beta_0 + \beta_1 \text{Education} + \beta_2 \text{Age} + \beta_3 \text{WM} + \beta_4 \text{First Response} + \beta_5 \text{Age} * \text{WM} \\ & + \beta_6 \text{Age} * \text{First Response} + \beta_7 \text{WM} * \text{First Response} + \beta_8 \text{Age} * \text{WM} \\ & * \text{First Response} + e_i \\ \text{where } e_i \sim & N(0, \sigma_e^2) \end{aligned}$$

- Compare correlations on the happiness questions (part-whole)



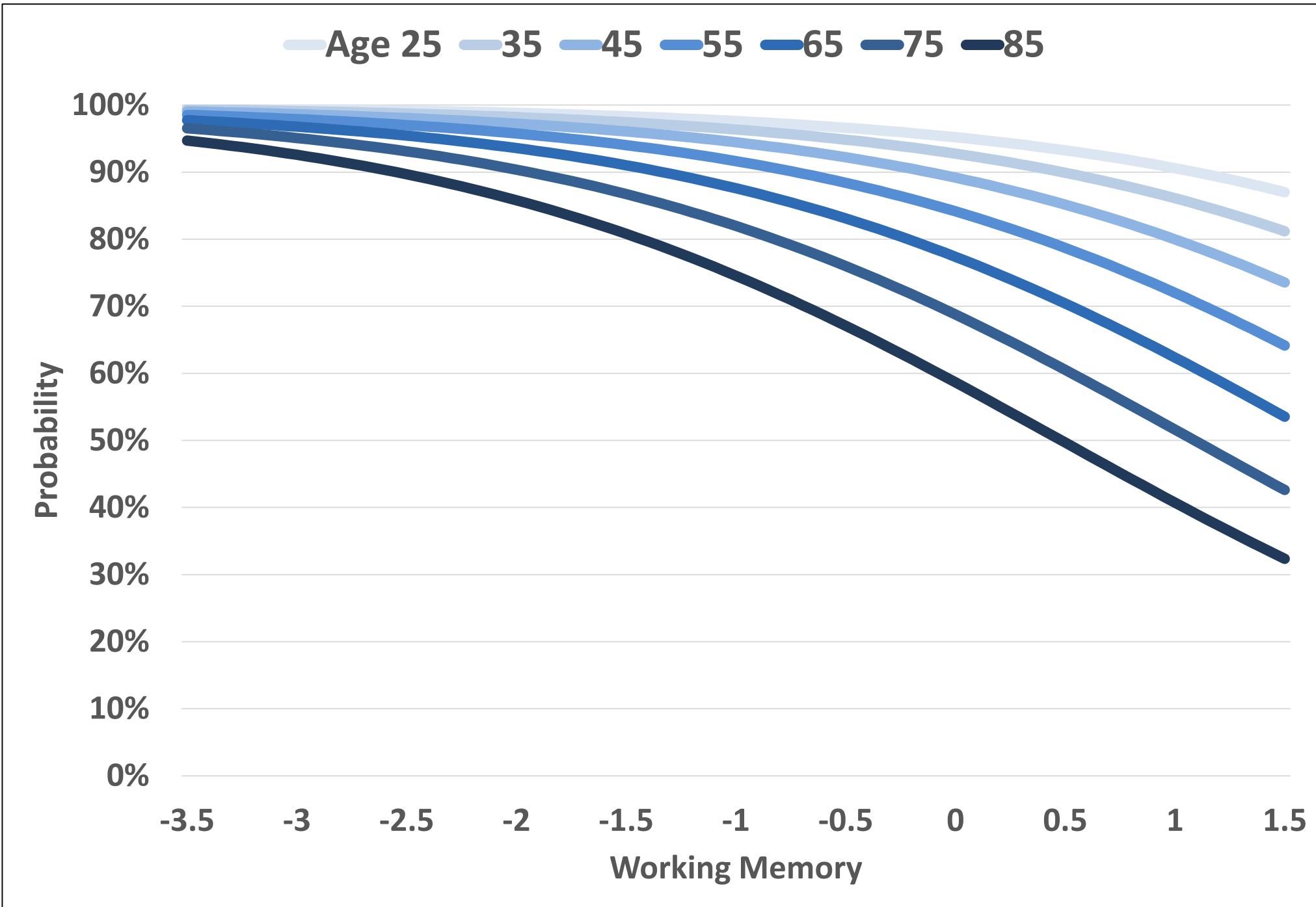
- ❑ Logistic regression
  - Only significant predictor is response to the previous question
  
- ❑ Comparing correlations
  - Telephone high working memory - contrast effect
    - Altogether asked first  $r_{\phi}=0.4085$
    - Partner asked first  $r_{\phi}=0.2208$
    - $z=1.32, p=.09$

# Results – Labor Questions

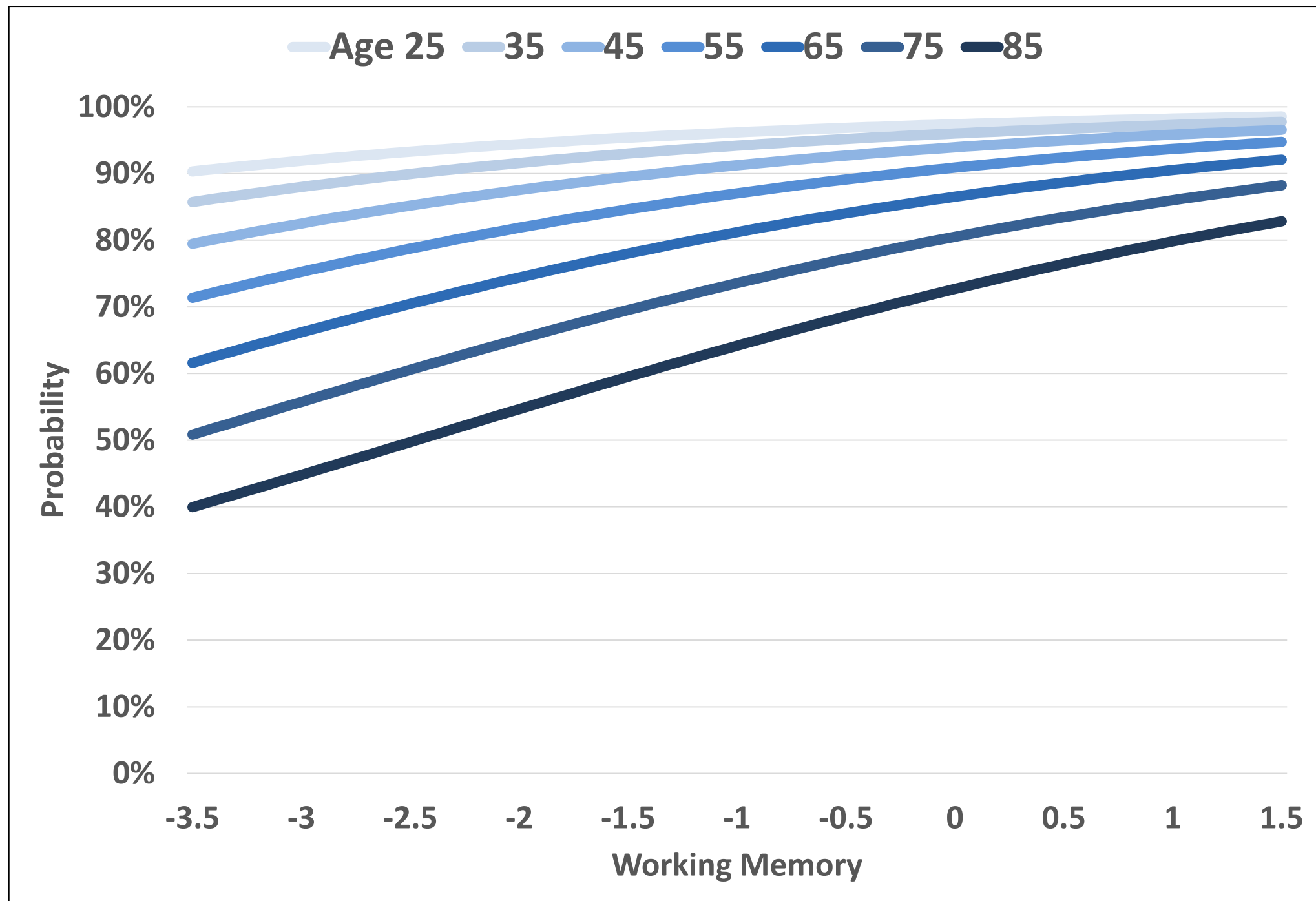


Age ( $p < .05$ ), WM ( $p < .10$ ),  
WM\*Answer ( $p < .10$ )

### Probability of Selecting Yes to Workers' Right to Strike when Answer Yes to Employers' Right to Shutdown – Telephone



### Probability of Selecting Yes to Workers' Right to Strike when Answer No to Employers' Right to Shutdown – Telephone





- ❑ Part-part or part-whole?
- ❑ Defect asked first:
  - ❑ Previous answer is only significant predictor
- ❑ Married asked first: (telephone)
  - ❑ Yes to Married – highly likely to say yes to Defect, little variation across working memory
  - ❑ No to Married – A decline in the estimated probability of selecting Yes to Defect





- ❑ Only moderate evidence that question order effects are influenced by working memory
- ❑ The limited significant results were found only in Telephone
- ❑ High percentage of respondents provide the same response to both questions (60-85%)
  - Unable to disentangle a consistent thoughtful response and a consistent response as a result of satisficing



# Comparison to HRS Measures



- ❑ Comparing the working memory measures and a subset of HRS memory measures
  
- ❑ Competing hypotheses
  - No differences – capturing highly related constructs
  - Significant differences – capturing different aspects of memory



- ❑ Paired t-test to compare means
- ❑ Simple linear regression to determine the correlation
- ❑ Determine the percentage of respondents classified differently, high vs. low
- ❑ Substitute HRS scores into earlier model with significant WM results



Paired t-test

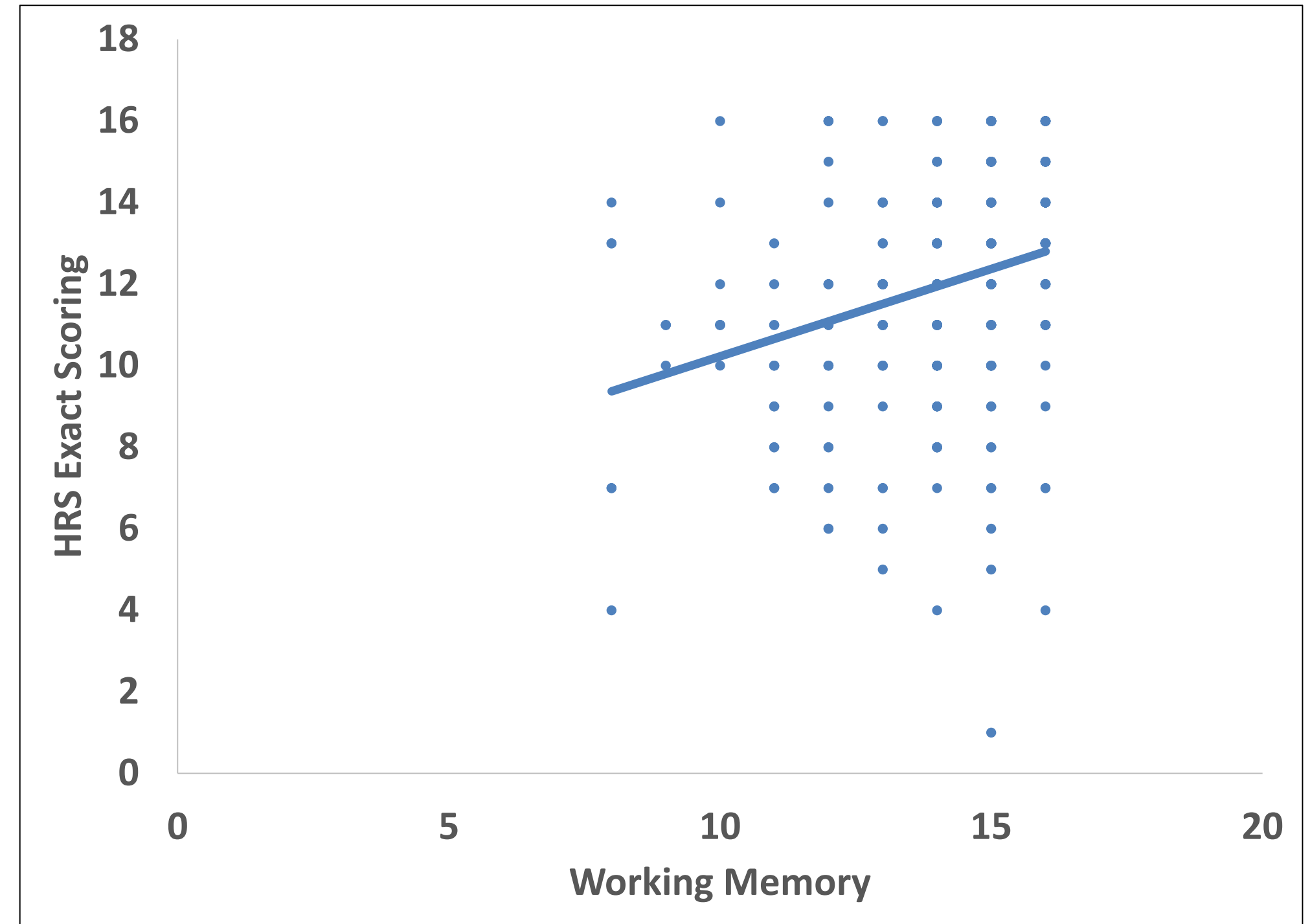
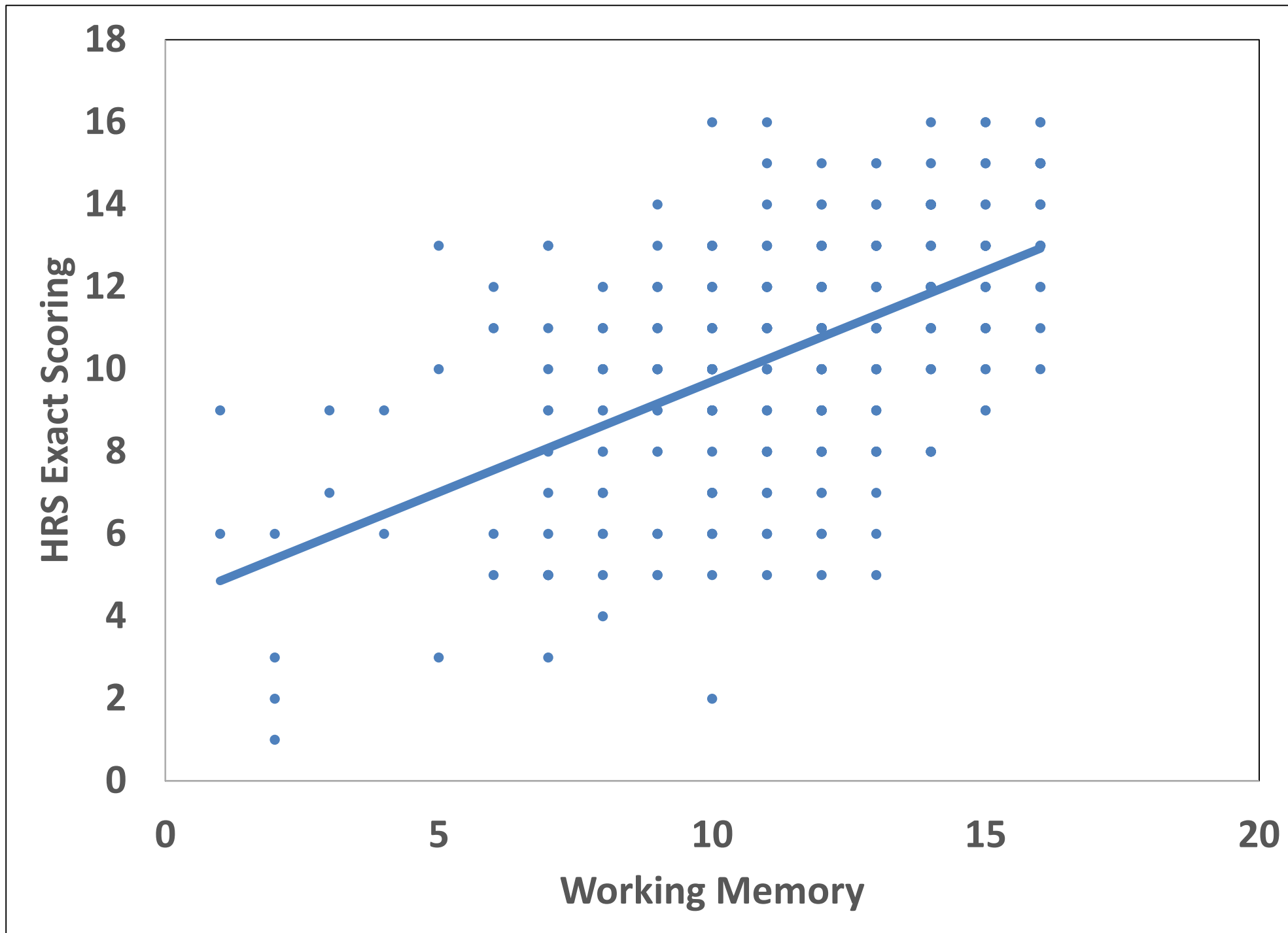
	n	Working Memory $\bar{X}$	HRS Exact $\bar{X}$	Difference	t	p-value
Telephone	341	11.38	10.44	0.94	6.34	<.0001
Web	260	13.93	11.91	2.02	11.04	<.0001

# Results – Linear Regression



**Telephone**  
 **$r=0.5063$**

**Web**  
 **$r=0.2889$**



# Results – High/Low Classifications (Median Split)



## ☐ Telephone (24.4%)

		HRS Exact Values		
		<u>Low</u>	<u>High</u>	Total
Working Memory	<u>Low</u>	129 (51.6%)	49 (19.6%)	178 (71.2%)
	<u>High</u>	12 (4.8%)	60 (24.0%)	72 (28.8%)
Total		141 (56.4%)	109 (43.6%)	250

## ☐ Web (29.3%)

		HRS Exact Values		
		<u>Low</u>	<u>High</u>	Total
Working Memory	<u>Low</u>	49 (28.2%)	18 (10.3%)	67 (38.5%)
	<u>High</u>	33 (19.0%)	74 (42.5%)	107 (61.5%)
Total		82 (47.1%)	92 (52.9%)	174



- Model
  - Predicting the Probability of Selecting a Late Response Option (Across Q4-Q6)
  
- Working Memory Measures
  - Significant Predictors: WM\*Mode, Age\*WM\*Mode
  
- HRS Measures
  - No Significant Predictors





- Overall, the tests indicate that the working memory measures and HRS memory measures reflect different cognitive constructs.
  - HRS measures do not adequately reflect working memory capacity.



# Conclusions and Contributions to CASM



- Evidence supports that working memory can influence response order effects
  - However, effects are not consistent across age and mode
  - Agree with previous recommendations that response options should be randomized
  - More research needed to look at the adverse effects on older respondents
- Little support that working memory influences question order effects
  - Unable to disentangle the consistent answers to both questions
  - Future studies needed to examine cognitive processes influencing question order effects
- HRS memory measures capture different cognitive constructs than working memory measures
  - Recommend HRS and similar studies incorporate measures designed to reflect working memory capacity



# Limitations



- ❑ Administration of memory measures
  - Lack of controlled environment
  - Across two modes
- ❑ Possible respondent fatigue
- ❑ Attitudinal questions for response order effects
  - Not pre-tested
  - No variety in types of questions
- ❑ Including Don't Know & Refuse options on Web
  - May have influenced visual attention on substantive options
- ❑ Respondent ages skewed slightly older
- ❑ Administered only in a politically conservative state
- ❑ Series of models, p-values may not reflect true significance



**Thank you**

## Response Order Questions



Of the following, which type of book do you prefer to read?

Fiction, Non-fiction

Of the following, which type of movie do you prefer to watch?

Action; Drama

Of the following, which type of performance to you prefer to attend?

Broadway Musical; Classical Ballet

Of the following, which type of music do you prefer to listen to?

Rock; Country; Pop; Rap; R&B; Gospel

Of the following, which type of sporting event do you prefer to watch?

Basketball; Soccer; Baseball; Hockey; Golf; Volleyball

Of the following, which type of attraction do you prefer to visit?

Art Museum; Amusement Park; Historical Monument; State Capitol Building; Science Museum; National Park

## Question Order Questions



Taken altogether, how would you say things are these days: would you say that you are very happy, somewhat happy, or not too happy?

Taking things altogether, how would you describe your relationship with your intimate partner: would you say that in your relationship with your intimate partner you are very happy, somewhat happy, or not too happy?

Do you believe that workers and unions have the right to strike when wages and working conditions don't suit them?

Do you believe that businessmen have a right to shut down their factories and stores when labor conditions and profits don't suit them?

Do you think it should be possible for a pregnant woman to obtain a legal abortion if she is married and does not want any more children?

Do you think it should be possible for a pregnant woman to obtain a legal abortion if there is a strong chance of serious defect in the baby?





## True/False Sentence Span

Fish walk on *land*.

Airplanes are faster than *trains*.

The taste of sugar is *sweet*.

You can sit on a *chair*.

Babies can drive *cars*.

## Alphabet Span

*Rock*

*Blood*

*Shoes*

*Girl*

*Earth*



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Fish walk on *land*.

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# HRS 10 Words to Recall

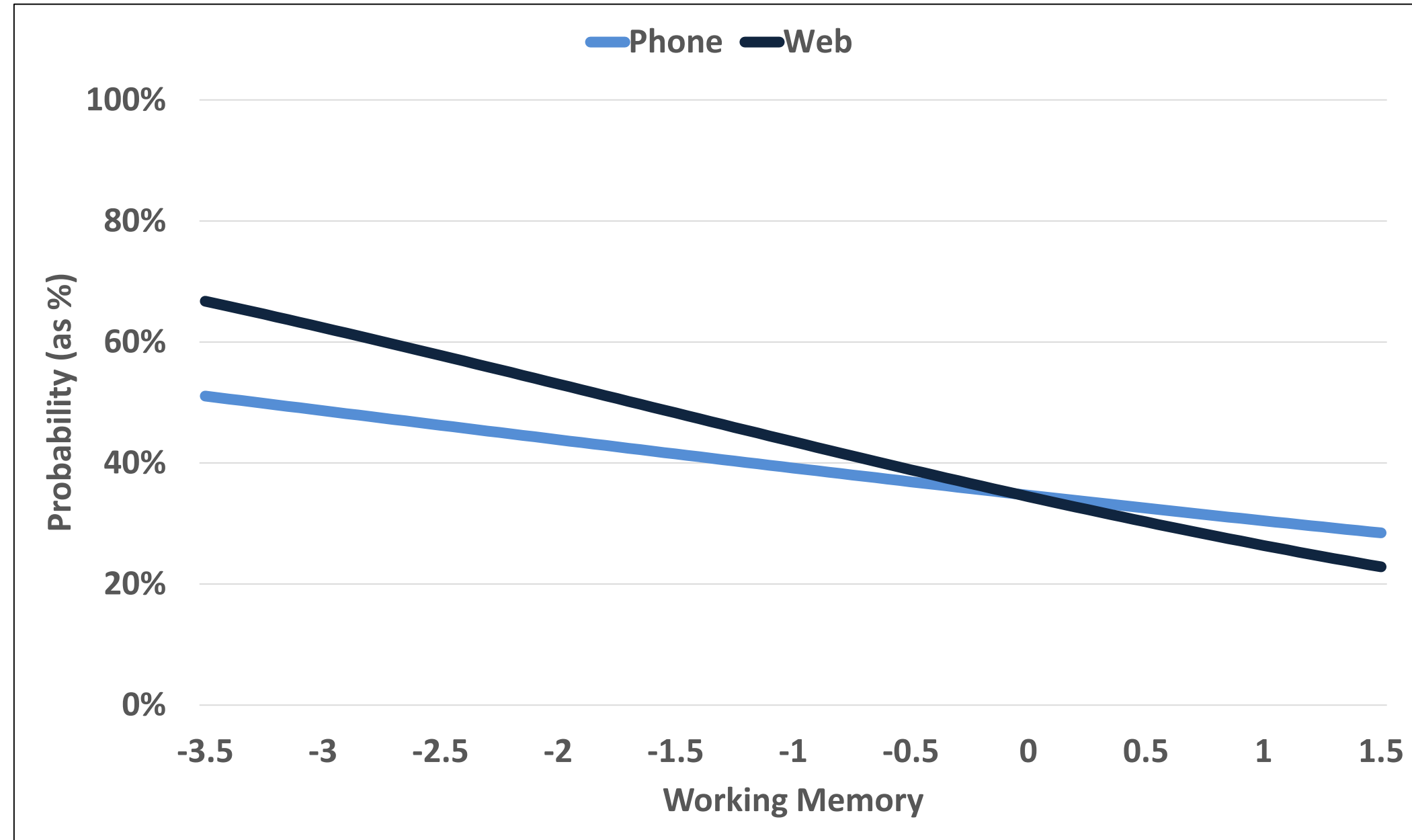


Hotel  
River  
Tree  
Skin  
Gold  
Market  
Paper  
Child  
King  
Book

# Predicting Early Response Option (Across Q4-Q6)



WM\*Mode (p<.10)



# Probability of Selecting the First Response Option (Across Q1-Q3) – Combined Modes



Mode (p<.01), Age\*Mode (p<.01), Age\*WM\*Mode (p<.10)

	Coef.	SE				
Intercept	0.205	0.313		Age	-0.005	0.004
				Working Memory	0.392	0.283
Question Number:				Mode:		
(Ref) Q1	--	--		(Ref) Telephone	--	--
Q2	0.041	0.119		Web	-1.05	**
Q3	-0.160	0.123				
Education:				Age*WM	-0.007	0.004
(Ref) ≤ H.S. grad	--	--		(Ref) Age*Phone	--	--
Tech/Trade/Assoc.'s	0.035	0.186		Age*Web	0.020	**
Some college	0.295	0.210		(Ref) WM*Phone	--	--
Bachelor's degree	-0.015	0.181		WM*Web	-0.679	0.432
Post grad degree	0.010	0.182		(Ref)Age*WM*Phone	--	--
				Age*WM*Web	0.012	+

# Probability of Selecting a Late Response Option (Across Q4-Q6) – Combined Modes



WM\*Mode (p<.05),  
Age\*WM\*Mode (p<.05)

	Coef.	SE				
Intercept	-0.465	0.333		<u>Predictors</u>		
				Age	-0.001	0.005
				Working Memory	-0.232	0.296
<u>Controls</u>				Mode:		
Question Number:				(Ref) Telephone	--	--
(Ref) Q4	--	--		Web	-0.121	0.429
Q5	-0.196	0.127		<u>Interactions</u>		
Q6	-0.125	0.123		Age*WM	0.003	0.005
Education:				(Ref) Age*Phone	--	--
(Ref) ≤ H.S. grad	--	--		Age*Web	0.001	0.007
Tech/Trade/Assoc.'s	0.005	0.204		(Ref) WM*Phone	--	--
Some college	-0.109	0.231		WM*Web	1.077	* 0.466
Bachelor's degree	0.071	0.199		(Ref)Age*WM*Phone	--	--
Post grad degree	0.088	0.200		Age*WM*Web	-0.017	* 0.007

# Results – Labor Questions



Age (p<.05), WM (p<.10),  
WM\*Answer (p<.10)

	Model 4					
	Coef.		SE			
Intercept	4.085	*	1.633	1 <sup>st</sup> Question Answer:		
				(Ref) Yes	--	--
Education:				No	0.573	0.701
(Ref) ≤ H.S. grad	--		--			
Tech/Trade/Assoc.'s	0.858		0.952	Age*WM		
Some college	1.242		1.366	(Ref) Age*1 <sup>st</sup> Yes		
Bachelor's degree	0.041		0.902	Age*1 <sup>st</sup> No		
Post grad degree	0.809		0.960	(Ref) WM*1 <sup>st</sup> Yes	--	--
				WM*1 <sup>st</sup> No	1.121	0.670
Age	-0.044	*	0.022	(Ref)Age*WM*1 <sup>st</sup> Yes		
Working Memory	-0.725	+	0.422	Age*WM*1 <sup>st</sup> No		