



# Religiosity is Associated with Less Prediction of the Typical: An Event-Related Brain Potential Study

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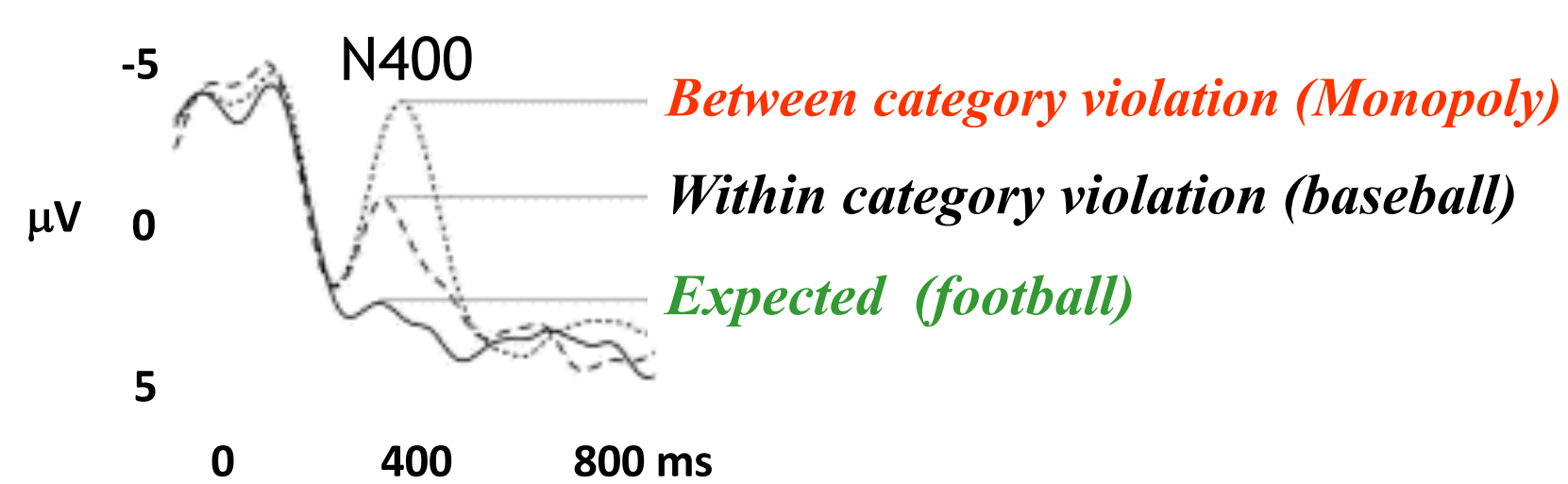
## Introduction

**Religiosity** is “the self-perceived importance of religion...to an individual – and the degree to which religious beliefs and identities translate into secular attitudes.”<sup>1</sup> Using **N400 event-related potentials (ERPs)**, we sought to investigate two information processing hypotheses that may relate to differences in religiosity. The **need for closure (NFC)** hypothesis proposes that people who strongly seek definitive explanations for inconclusive situations are more likely to be religious.<sup>2,4,7</sup> Alternatively, individuals with smaller “**prediction error**” signaling for unexpected stimuli may be less likely to discount evidence contradicting religious beliefs, predisposing them to develop or maintain such beliefs.<sup>8,9</sup>

N400 amplitude is smaller in response to contextually expected stimuli, reflecting a tendency to predict information that completes meaningful situations – a phenomenon referred to as the **N400 semantic priming effect** (Figure 1).<sup>5</sup>

We hypothesized that if the **NFC hypothesis** is true, *larger* N400 semantic priming effects between expected (high-typicality) and unexpected (low-typicality or unrelated) stimuli would correlate with both NFC and religiosity. In contrast, we hypothesized that if the **prediction error hypothesis** is true, *smaller* N400 semantic priming effects would correlate with higher religiosity.

*He caught the pass and scored another touchdown. There was nothing he enjoyed more than a good game of ... **football** / baseball / **Monopoly***

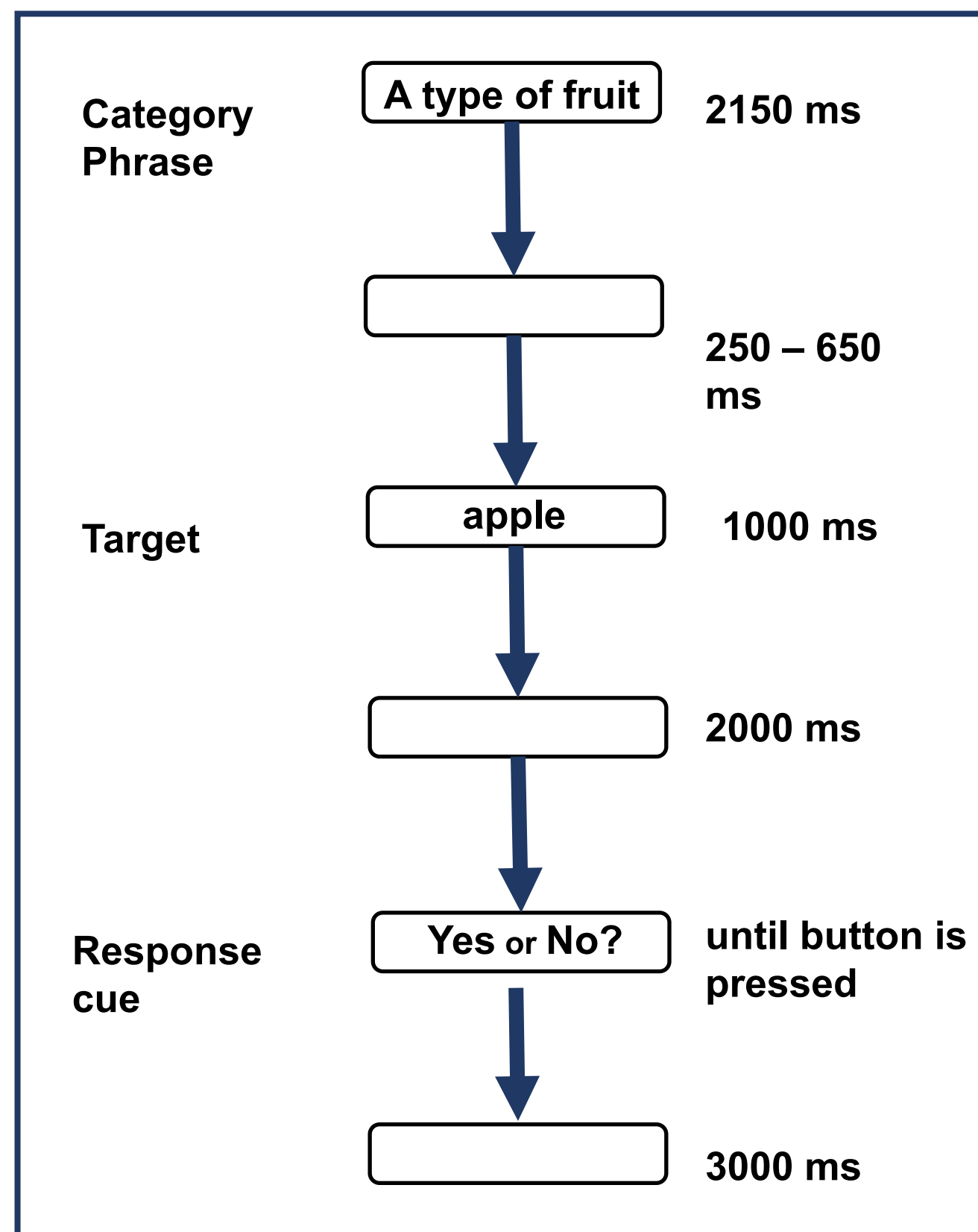


Federmeier & Kutas, 1999

**Figure 1 (above):** N400 is a negative-going ERP waveform occurring around 400 ms after any potentially meaningful stimulus. It is smaller (less negative) when the eliciting stimulus is more expected in its context.<sup>5</sup>

## Methods

<b>Sex</b>	6 female, 12 male
<b>Age</b>	mean 23.1 yrs. (SD = 3.5, range 18-32)



**Figure 2 (left):** On each of 120 trials, participants were presented with a category phrase (e.g. *a type of fruit*), followed by a target word that was either a: a) high-typicality exemplar (e.g. *apple*), b) low-typicality exemplar (e.g. *mango*), or c) unrelated non-exemplar (e.g. *clamp*). For each trial type, N400 amplitude was measured as mean voltage of the averaged ERP from 350-550 ms post-stimulus onset.

### Need for Closure Scale (NFCS)<sup>4</sup> – Example Items

- “I dislike questions that could be answered in many different ways.”
- “I feel uncomfortable when I don’t understand the reason why an event occurred in my life.”
- “I enjoy the uncertainty of going into a new situation without knowing what might happen.”

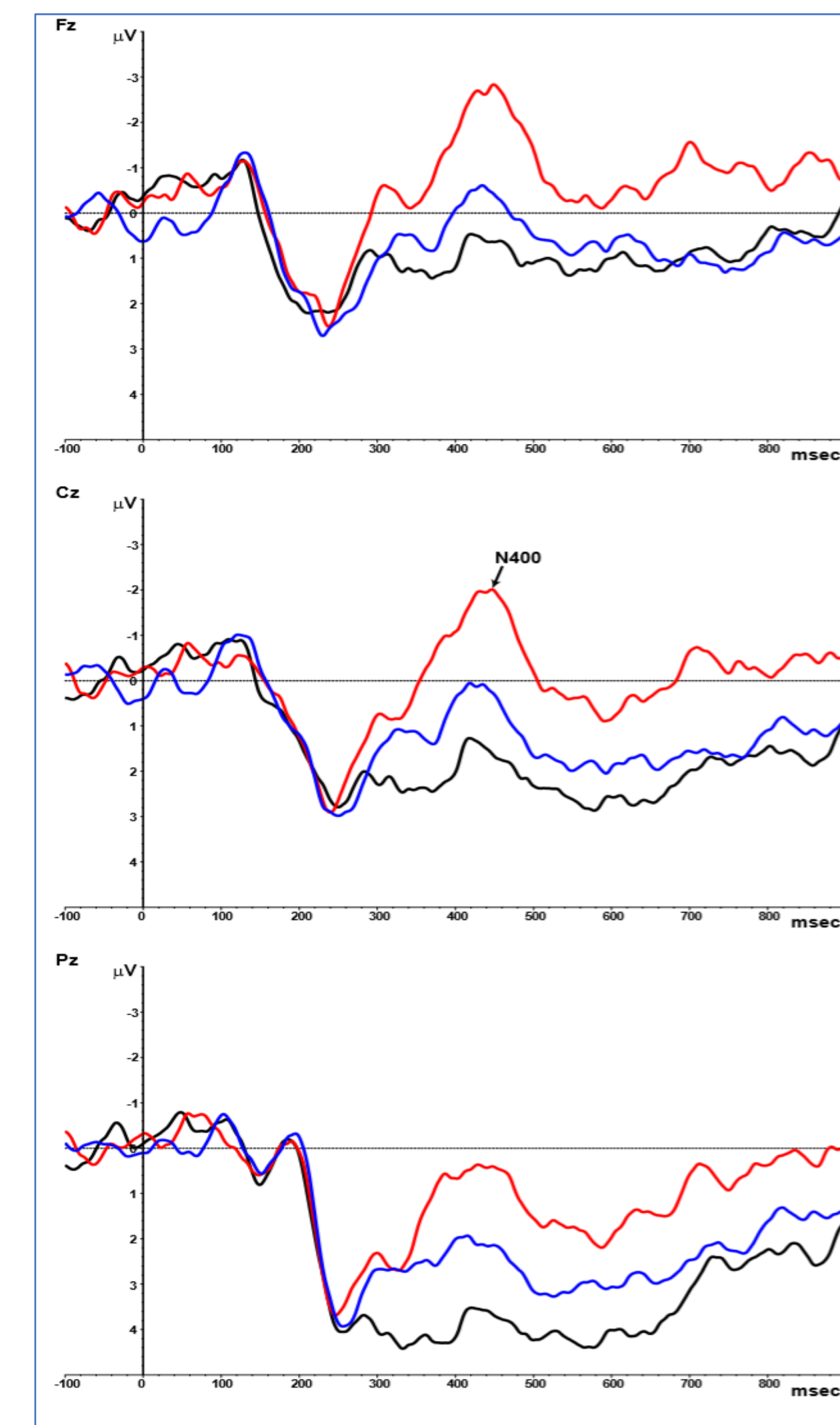
The NFCS is a 42-item self-report questionnaire. Each item is rated on a 6-point Likert scale from 1 (“Strongly disagree”) to 6 (“Strongly agree”). Higher scores on the NFCS indicate higher NFC.

### Religiosity Scale<sup>3</sup> – Factors with Example Items

General Religiosity	“I find strength and comfort in my religion.” “My faith in God shapes how I think and act everyday.”
Social Religiosity	“Most of my best friends are religious.”
Involved God	“I believe that God frequently alters the course of human events.”
Forgiveness	“I try to be forgiving toward other people.”
God as Judge	“I believe that God will punish me if I do something wrong.”
Unvengefulness	“It is all right to get back at someone who hurts or offends you.”
Thankfulness	“I feel grateful nearly every day.”

A 78-item self-report questionnaire was used to measure 7 factors of religiosity.<sup>3</sup> Each item was weighted equally, and the numerical scores standardized such that the maximum possible score for each item was 4.0. Each participant’s overall religiosity was quantified as the total score for all 78 items, with higher scores indicating higher religiosity.

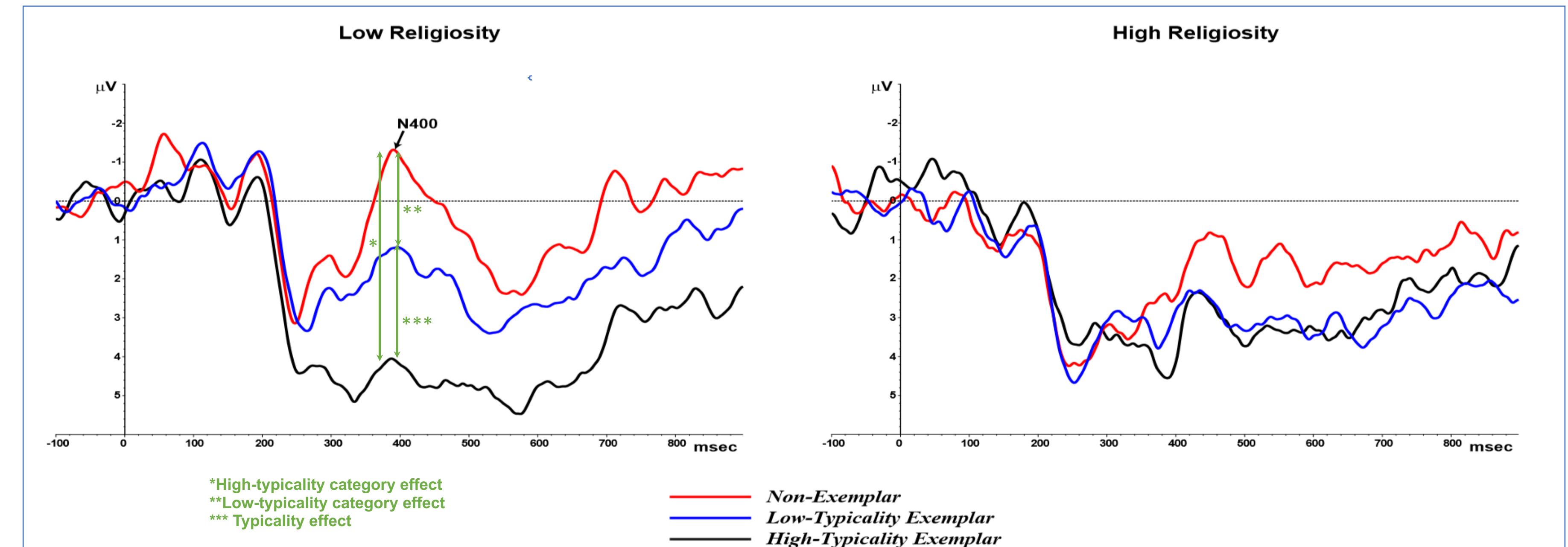
## Results



**Figure 3 (left):** Grand average ERPs for the three target types, at electrode sites Fz, Cz, and Pz.

— Non-Exemplar  
— Low-Typicality Exemplar  
— High-Typicality Exemplar

**Figure 4 (below):** Grand average ERPs at electrode site Pz for low-religiosity and high-religiosity subsamples, formed by median split on overall religiosity.



	1	2	3	4	5	6	7
1. N400 high-typicality category effect	-						
2. N400 low-typicality category effect	<b>0.54*</b>	-					
3. N400 typicality effect	<b>0.80*</b>	-0.07	-				
4. NFC	0.00	<b>0.47*</b>	-0.41	-			
5. General religiosity	<b>0.56*</b>	0.28	0.47	0.18	-		
6. Forgiveness	<b>0.50*</b>	0.18	0.46	-0.27	<b>0.52*</b>	-	
7. Unvengefulness	-0.32	<b>-0.50*</b>	-0.02	<b>-0.55*</b>	0.14	0.31	-
8. Overall Religiosity	<b>0.53*</b>	0.20	<b>0.49*</b>	0.04	0.97	<b>0.63*</b>	0.29

\* $p < 0.05$ , \*\* $p < 0.001$ , \*\*\* $p < 0.0001$ . Positive correlation coefficients indicate that higher NFC or religiosity scores correlated with smaller N400 priming effects (i.e., smaller N400 amplitude differences between conditions).

## Conclusions

**Higher overall religiosity** was associated with **smaller N400 semantic priming effects** for high-typicality exemplars relative to low-typicality exemplars and non-exemplars, consistent with the predictive processing model of religiosity.

The results suggest that individuals with less prediction error signaling may be more predisposed to develop or maintain religious beliefs.<sup>8,9</sup>

## Acknowledgements

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