

Religious-Commitment Signaling and Impression Management amongst Pentecostals: Relationships to Salivary Cortisol and Alpha-Amylase

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Abstract

Religious-commitment signaling is thought to indicate willingness to cooperate with a religious group. It follows that a desire to signal affiliation and reap concomitant benefits would lend itself to acting in socially desirable ways. Success or failure in such

areas, especially where there is conscious intent, should correspond to proximal indicators of well-being, such as psychosocial or biological stress. To test this model, we assessed religious-commitment signaling and socially desirable responding among a sample of Pentecostals with respect to salivary biomarkers of stress and arousal. Results indicate that cortisol levels on worship and non-worship days were significantly influenced by religious-commitment signaling when moderated by impression management, a conscious form of socially desirable responding. No significant influences on salivary alpha-amylase were detected. These findings are important for understanding how religious-commitment signaling mechanisms may influence stress response when moderated by socially desirable responding and the role of communal orientation to psychosocial health.

Keywords

alpha-amylase – cortisol – impression management – Pentecostalism – religious-commitment signaling – stress

1 Introduction

“Religious-commitment signaling” involves behaviors thought to indicate willingness to cooperate with a religious group (Bulbulia and Sosis, 2011). It follows that a desire to signal affiliation of religious group membership and reap concomitant benefits would lend itself to acting in ways considered socially desirable to the group. Success or failure in signaling or in behaving in desirable ways, especially when the intent to do so is conscious, should correspond to proximal indicators of stress, such as physiological biomarkers. To test this model, we assessed religious-commitment signaling and socially desirable responding among a sample of Pentecostals with concurrent measurement of stress and arousal biomarkers in saliva. Because of links between religiosity and health (e.g., Uchino, 2006; Koenig, 2009; Ellison and Hummer, 2010), this study is important for understanding how religious-commitment signaling mechanisms and stress may be moderated by socially desirable responding.

Scholars have long sought to understand religio-cultural behaviors that incur non-survival costs to individuals (Sosis, 2006), such as genital alterations of children as part of religious rites of passage, bodily exposure to angry insect swarms, and other rituals of pain or hardship that defy straightforward

explanations (Tuzin, 1982; Glucklich, 2001). A cognitive science approach has developed that explains such behaviors as “costly honest signals,” “hard-to-fake signs of commitment,” or “religious-commitment signals” (Cronk, 1994; 2005; Irons, 2001; Sosis and Alcorta, 2003; Sosis, 2004, 2006; Alcorta and Sosis, 2005; Sosis et al., 2007; Bulbulia, 2008). This model derives most recently from the “handicap principle” of animal behavior but was anticipated by theories of conspicuous consumption (Veblen, 2007 [1899]), commitment signaling (Schelling, 1960), job market signaling (Spence, 1973), and emotions as hard-to-fake signals (Hirschleifer, 1987; Frank, 1988, 1993).

Costly honest religious behaviors are considered culturally relative indicators of willingness to cooperate. Such indications are especially important when group stability is precarious (Sosis, 2006). It follows that communities would favor these symbolic expressions if membership provides access to limited resources, including goods, services, or simply the reciprocal altruism of social support. Yet studies have found costliness less critical to signaling than being hard to fake (Irons, 2001, 2008) or “credibility-enhancing” (Henrich, 2009). Religious communities characterized by hard-to-fake signaling are more stable and cooperative than similar non-signaling groups whether they are marginal or not (Sosis and Bressler, 2003; Sosis and Ruffle, 2003).

Religious-commitment signaling theory is receiving increasing attention, but empirical testing is still in its infancy. Studies of Israeli kibbutzim and Brazilian Candomblé indicate that religious commitment predicts in-group cooperation (Sosis and Ruffle, 2003; Soler, 2008, 2012), but applications of commitment signaling theory have not been made with regard to Christianity. Pentecostalism affords an ideal test because it was part of the most successful Christian movement of the twentieth century (Cox, 1995; Cleary, 1997;). As an evangelical form of Protestantism, Pentecostalism is beset by the “free-rider” problem associated with institutions dedicated to social support (Simpson, 2012) but is characterized by speaking in tongues, a nonsensical linguistic behavior attributed to possession by the Holy Spirit and commitment signal *par excellence*. To in-group members, speaking in tongues is the sign that one has accepted Jesus but is often characterized as odd or weird to non-Pentecostal outsiders (Lynn, 2013) and was previously attributed to mental disturbance (Hine, 1969; Richardson, 1973; Kay and Francis, 1995). To become a Pentecostal, there is thus a motivation to impress others within the group and distinguish oneself from outsiders through speaking in tongues.

Behaving in ways to impress others, termed “socially desirable responding,” has been positively correlated with intrinsic religiosity and supports the notion that religiosity is a basic means of self-enhancing to improve psychosocial health (Sedikides and Gebauer, 2010). Impression management, or the conscious tailoring of self to impress others – as opposed to self-deceptive enhancement, or the unconscious intent to impress – is consistently higher among the devoutly religious (Trimble, 1997; Sedikides and Gebauer, 2010). The better-than-average effect, which is the belief that one is better than average on desirable characteristics, is associated with religiosity cross-culturally, but only with regard to out-group members (Eriksson and Funcke, 2014). The better-than-average effect, also known as “positive illusions,” has been associated with psychological benefits (Taylor and Brown, 1994; Taylor and Armor, 1996; Johnson, 2004), but it remains to be seen whether there is an interaction with religiosity or if psychological benefits extend to physical benefits, which can be tested through biomarkers like cortisol and alpha-amylase.

As part of human stress response, cortisol is a glucocorticoid that acts to divert energy from non-essential systems and facilitate glucose mobilization, among other functions. Alpha-amylase is an enzyme present in saliva that is involved in starch breakdown and secreted coincident with epinephrine production. Epinephrine is a stress hormone associated with sympathetic nervous system activity produced immediately in response to sudden arousal, whereas the activities of cortisol have an approximately 15-minute latency in onset and cessation. High stress lifestyles and over-active arousal and stress response have been linked to a host of metabolic and chronic disorders (Sapolsky, 2002), so production of these mechanisms can be used as approximate indicators of stress reactivity and indirect links to health.

A model designed to assess the influence of religious-commitment signaling on health indicators like stress response should take into account an array of public behaviors, such as the seemingly irrational behaviors like glossolalia, the opportunity costs of attending numerous worship services every week, other indicators of sacrifices to participate in and be members of a religious group, and the desire of individuals to impress their commitment on others. To do this, we developed a metric of religious-commitment signaling and examined its influence, moderated by socially desirable responding, on cortisol and alpha-amylase among a sample of Pentecostals. We predicted that greater benefits should accrue to individuals who exhibit greater commitment signaling and behave in ways appealing to their religious group.

2 Methods

2.1 *Participants*

Data were collected from 52 Pentecostals at two churches in Poughkeepsie and Kingston, NY from 2007–2009 as detailed elsewhere (Lynn et al., 2010, 2011; Lynn, 2013). These congregations were chosen based on their shared doctrine and proximity to each other, as they are located in small adjacent cities in New York's Hudson Valley. Poughkeepsie and Kingston are characterized by relatively low socio-economic demographic profiles with 20% of their citizens below poverty level. The churches are located in poorer neighborhoods of these cities, neighborhoods populated predominantly by an immigrant and African-American demographic. In fact, members of the Poughkeepsie church in the study were predominantly Jamaican immigrants, while the other was more ethnically-diverse.

Socially desirable responding data were collected during the first half of data collection, but this questionnaire was later dropped from the study design to reduce participant burden and improve compliance. Thus, a subsample of 25 (72% from Poughkeepsie church) provided all the data for these analyses, including 12 females and 13 males, ages 18–69 (mean \pm SD = 37.0 \pm 12.64). Sixty percent reported as being in a committed relationship, and the same percentage reported having children. The majority (80%) had at least a high school diploma and self-rated their social status as average or better (76%). As would be expected of evangelical church members, 48% reported at least 1–5 people nearby they could count on in times of need. Because these participants represent the first half of the data collection period, there may be a bias toward participants more willing to respond favorably to participating in a study as suggested by a higher rate of religious-faith signaling among this subsample ($p = 0.01$). The only other differences between those who completed the BIRD and those who did not was a greater mean age ($p = 0.02$), number of children ($p = 0.02$), and representation of the Kingston church ($p < 0.001$) among the former.

2.2 *Procedures*

Qualitative observations and semi-structured interviews were used to develop a relevant survey to assess glossolalia (Lynn et al., 2011). Participants were recruited directly by the first author and research assistants and issued kits containing a paper survey and saliva collection tubes and oral swabs (Salimetrics, State College, PA, USA). Secretion of cortisol and alpha-amylase fluctuate daily and therefore must be sampled over the course of a day, but they can

be easily and non-invasively extracted from saliva (Lovallo and Thomas, 2000; Kirschbaum and Hellhammer, 2007; Nater et al., 2007; Hellhammer et al., 2009; Nater and Rohleder, 2009). Following a minimal protocol (Adam and Kumari, 2009) to maximize compliance and accommodate church services, participants were asked to collect their own saliva at prescribed times (10 AM, 2:30 PM, 6 PM and 10 PM) on Sunday (the worship day) and Monday (the non-worship day) and to complete the survey during the same week.

All protocols were approved by the University at Albany Institutional Review Board.

2.3 *Religious-Commitment Signaling*

Following Soler (2012), a culturally-relative index of “religious-faith signaling” was developed to include the common religiosity dimensions of attendance, giving, and participation. The fourth dimension commonly included in religiosity scales is salience, which was excluded because it relates to inner belief that cannot be readily observed as a signal of commitment. The religious-faith signaling index was composed *ex post facto* by summing observational and questionnaire items that represented visual displays of religiosity or faith. Items included a dichotomous index of church status, 4 items from the Glossolalia Experiences Questionnaire (Lynn et al., 2011), 3 items from the Religiosity Measures Questionnaire (Rohrbaugh and Jessor, 1975), and 17 items from the Faith Maturity Scale (Benson et al., 1993). Church status was determined by the first author using ethnographic data in accordance with Williams’ (1984) Pentecostal church hierarchy, which includes elite (pastor and those with direct influence on pastoral decisions), core (other officers or individuals with church service positions), supportive (“Sunday Christians”), and marginal (children, infirm, newcomers, and “backsliders”). Categories were collapsed as either elite/core or marginal/supportive for analytical utility and because distinctions within these dichotomies were less clear than between them. The Glossolalia Experiences Questionnaire queries how many overall glossolalia experiences a person has had and the average qualities of those experiences, the Religiosity Measures Questionnaire measures impact of religious behavior on daily life (Boivin, 1999), and the Faith Maturity Scale measures the degree to which a person embodies faith (Tisdale, 1999).

The 25 items of this “religious-faith signaling” scale were subjected to principal components analysis. The presence of many coefficients of 0.30 and above in the correlation matrix indicated suitability of the data for factor analysis. The Kaiser-Meyer Oklin value was 0.75, exceeding the recommended value of 0.6 (Kaiser, 1970, 1974), and Barlett’s Test of Sphericity (1954) reached statistical significance, supporting the factorability of the correlation matrix. Principal

components analysis revealed the presence of 7 components with eigenvalues exceeding 1, but an inspection of the scree plot revealed a clear break after the second component. Following Cattell (1966), it was decided to retain two components for further investigation. This was supported by the results of parallel analysis, which showed only two components with eigenvalues exceeding the corresponding criterion values for a randomly generated data matrix of the same size. The two-component solution explained a total of 55.4% of the variance, with component 1 contributing 37.4% and component 2 contributing 18.0%. To aid in the interpretation these two components, oblimin rotation was performed. The rotated solution revealed the presence of simple structure (Thurstone, 1947), with both components showing a number of strong loadings and all but one variable loading substantially on only one component. All the variables loading on the first component were from the Faith Maturity Scale and were interpreted as representing “faith-signaling,” while the rest of the variables loaded on the second component, which was interpreted as representing “religious-commitment signaling.” There was a weak correlation between the two factors ($r = 0.14$), which supports the use of the faith- and religious-commitment signaling as separate scales of visible religiosity. Cronbach’s alphas based on standardized items were 0.87 for faith-signaling, 0.73 for religious-commitment signaling, and 0.79 for the full religious-faith signaling scale, indicating excellent reliability.

2.4 *Socially Desirable Responding*

Socially desirable responding was measured using the Balanced Inventory of Desirable Responding (BIDR) (Paulhus, 1991). The BIDR is a reliable and valid 40-item questionnaire with two sub-scales that measure self-deceptive enhancement and impression management, which are the tendencies to favorably promote oneself unconsciously and consciously, respectively. The BIDR was designed for the subscales to be used separately to detect these two modes of response bias or to be summed as a general measure. Scoring was done using the continuous approach (Stöber et al., 2002), and reliability coefficients were 0.69, 0.79 and 0.87 for self-deceptive enhancement, impression management, and overall socially desirable responding, respectively.

2.5 *Cortisol and Alpha-Amylase Assays*

Saliva samples were initially refrigerated after collection then transferred to a -34°C freezer. Samples were analyzed at the University at Albany (Albany, NY, USA) using commercial enzyme immunoassay kits (Salimetrics). Assays were analyzed following manufacturer’s instructions. Plates were read by a Bio-Tek automated microplate reader at 450 nm optical density. All samples including

standard curve (0–3 µg/dl) and unknowns were run in duplicate and outcomes averaged. Wells containing known high and low cortisol concentrations were used to correct for multiple plate comparisons and indicated normal lab intra-assay variation (%CV) of 5.2% for cortisol and 4.1% for alpha-amylase, and all inter-assay variances were <1% across assay plates.

2.6 Statistical Analysis

Analyses were conducted using SPSS 20 for Windows (IBM, Armonk, NY, USA). Descriptive statistics were calculated for the sample. Cortisol was transformed (\log_{10}) due to non-normalcy, and areas under the curve (AUC) were calculated for salivary cortisol (sCORT) and salivary alpha-amylase (sAA). The hypothesis that religious-commitment signaling would influence biomarkers of stress and arousal and be moderated by socially desirable responding was tested using hierarchical linear regressions with worship and non-worship day sCORT and sAA AUCs as dependent variables. Independent variables included the religious-commitment signaling (RCS) and faith signaling (FS) subscales and the full religious-faith signaling (RFS) scale. Moderators included the self-deceptive enhancement (SDE) and impression management (IM) subscales and socially desirable responding (SDR; the full BDR). Interaction terms were calculated for each combination using the cross-product of standardized independent and moderator variables (Dawson, 2014). To avoid limiting statistical power due to the relatively small sample size, separate models were tested for each independent and moderating variable combination (Cohen, 1988). *P*-values <0.05 were considered significant.

3 Results

Descriptive statistics are outlined in Table 1 and include the religious-faith signaling and BDR scales and their subscales. Cortisol measures are reversed due to log-transformation.

Hierarchical regressions were used to test the hypothesis that religious-commitment signaling influences stress and arousal and is moderated by socially desirable responding. The covariates sex and age were entered in the first step for each model. As indicated in Table 2, the covariate model for the worship day was significant and predicted 21% of the variation in cortisol. The independent variables of interest RFS, FS, or RCS and SDR, SDE, or IM were entered in the second step. All main effects models for cortisol on the worship day were significant, as were the models for RCS/IM, FS/IM, and RFS/IM on the non-worship day. Impression management was a significant predictor in the RCS/IM model on the worship and non-worship days and in the FS/IM and RFS/IM

TABLE 1 *Sample descriptives (N = 25)*

	Mean	SD	Min	Max
Religious-commitment signaling	41.6	14.55	11.33	62.00
Faith-signaling	90.4	15.77	41.00	119.00
Religious-faith signaling	132.1	22.34	52.33	162.33
Self-deceptive enhancement	89.1	16.53	62.00	122.00
Impression management	93.6	18.64	64.00	121.00
BIDR	179.0	35.44	92.00	241.00
sCORT AUC	Sunday -9.8	4.03	-17.82	-2.19
	Monday -10.9	4.05	-16.53	-0.35
sAA AUC	Sunday 1252.8	673.01	251.42	2607.31
	Monday 1454.7	837.92	304.04	2946.05

BIDR, balanced inventory of desirable responding; sCORT, salivary cortisol; sAA, salivary alpha-amylase; AUC, area under the curve.

models on the non-worship day. Socially desirable responding (SDR) was also a significant predictor in the RCS/SDR, FS/SDR, and RFS/SDR models on the non-worship day. These effects explained 21–35% of the variation in cortisol. Given the log-transformation of the cortisol values, these correlations suggest that as impression management and general socially desirable responding increase, stress decreases.

Interaction terms were entered in the third step. For worship day cortisol, all interaction models except the model for RCS \times SDE were significant (Table 2). The only significant interaction term was RCS \times IM, which explained 50% of the variation in cortisol. On the non-worship day, the models including RCS \times IM and RFS \times IM were significant, and, again, so was the RCS \times IM term, explaining 16% more of the variation in cortisol than the 29% explained by the main effects. However, the directions of these associations were the opposite of the associations for the main effects, suggesting that cortisol goes up when religious-commitment signaling is moderated by impression management.

For sAA (Table 3), none of the models for regressions were significant on the worship or non-worship day. The RFS \times IM term was significant on the worship day, and FS was a significant predictor in the FS/SDE model on both days. Taken together, these data indicate a large interaction effect between religious-

TABLE 2 *Worship and non-worship day salivary cortisol predicted by religious-faith signaling, socially desirable responding, and interactions using moderated linear regressions*

Step	Variable	Worship day cortisol (log ₁₀ AUC)				Non-worship day cortisol (log ₁₀ AUC)					
		Predictors		Model		Predictors		Model			
		β	SE	Sig.	adjusted r^2	Sig.	β	SE	Sig.	adjusted r^2	Sig.
1. Covariates	Age, sex				0.21	0.03				0.11	n.s.
2. Main effects	RCS	0.71	0.76	n.s.	0.25	0.04	-0.78	0.81	n.s.	0.16	n.s.
	SDE	0.93	0.80	n.s.			1.49	0.85	n.s.		
3. Interaction	RCS × SDE	1.04	1.06	n.s.	0.25	n.s.	0.50	1.15	n.s.	0.12	n.s.
2. Main effects	FS	0.85	0.73	n.s.	0.27	0.04	0.10	0.80	n.s.	0.12	n.s.
	SDE	0.97	0.77	n.s.			1.21	0.85	n.s.		
3. Interaction	FS × SDE	2.01	1.08	n.s.	0.35	0.02	1.03	1.27	n.s.	0.11	n.s.
2. Main effects	RFS	1.13	0.74	n.s.	0.30	0.02	-0.44	0.83	n.s.	0.13	n.s.
	SDE	0.75	0.79	n.s.			1.39	0.88	n.s.		
3. Interaction	RFS × SDE	1.30	0.93	n.s.	0.33	0.02	0.92	1.08	n.s.	0.12	n.s.
2. Main effects	RCS	0.78	0.69	n.s.	0.35	0.01	-0.60	0.73	n.s.	0.29	0.03
	IM	1.51	0.70	0.04			1.95	0.74	0.02		
3. Interaction	RCS × IM	-1.92	0.74	0.02	0.50	0.003	-1.96	0.78	0.02	0.45	0.01
2. Main effects	FS	0.71	0.70	n.s.	0.34	0.02	-0.10	0.75	n.s.	0.26	0.04
	IM	1.45	0.72	n.s.			1.89	0.76	0.02		

Step	Variable	Worship day cortisol ($\log_{10} \text{AUC}$)				Non-worship day cortisol ($\log_{10} \text{AUC}$)						
		Predictors		Model	Predictors		Model					
		β	SE	Sig.	adjusted r^2	Sig.	β	SE	Sig.	adjusted r^2	Sig.	
3.	Interaction	FS \times IM	0.95	1.27	n.s.	0.33	0.03	1.12	1.34	n.s.	0.25	n.s.
2.	Main effects	RFS	1.04	0.69	n.s.	0.38	0.01	-0.48	0.75	n.s.	0.28	0.04
		IM	1.35	0.70	n.s.			1.99	0.76	0.02		
3.	Interaction	RFS \times IM	-0.87	0.84	n.s.	0.38	0.01	-1.12	0.90	n.s.	0.30	0.04
2.	Main effects	RCS	0.72	0.71	n.s.	0.31	0.02	-0.71	0.75	n.s.	0.25	n.s.
		SDR	1.28	0.71	n.s.			1.78	0.74	0.03		
3.	Interaction	RCS \times SDR	-0.97	1.14	n.s.	0.30	0.03	-1.24	1.19	n.s.	0.25	n.s.
2.	Main effects	FS	0.76	0.70	n.s.	0.32	0.02	-0.03	0.76	n.s.	0.21	n.s.
		SDR	1.25	0.71	n.s.			1.64	0.76	0.04		
3.	Interaction	FS \times SDR	1.83	1.28	n.s.	0.35	0.02	1.21	1.43	n.s.	0.20	n.s.
2.	Main effects	RFS	1.05	0.70	n.s.	0.35	0.01	-0.50	0.77	n.s.	0.23	n.s.
		SDR	1.12	0.70	n.s.			1.78	0.77	0.03		
3.	Interaction	RFS \times SDR	0.15	1.04	n.s.	0.32	0.03	-0.22	1.13	n.s.	0.19	n.s.

RCS, religious-commitment signaling; IM, impression management; FS, faith signaling; RFS, religious-faith signaling; SDR, self-deceptive enhancement; SDR, socially desirable responding.

TABLE 3 *Worship and non-worship day salivary alpha-amylase predicted by religious-faith signaling, socially desirable responding, and interactions using moderated linear regressions*

Step	Variable	Worship day alpha-amylase (AUC)				Non-worship day alpha-amylase (AUC)					
		β	SE	Sig.	adjusted r^2	Model	β	SE	Sig.	adjusted r^2	Model
1. Covariates	Age, sex				-0.08						
2. Main effects	RCS	282.7	147.1	n.s.	-0.002		169.6	194.5	n.s.	-0.13	
	SDE	-92.0	154.8	n.s.			46.2	204.7	n.s.		
3. Interaction	RCS \times SDE	71.0	209.3	n.s.	-0.05		-209.9	273.4	n.s.	-0.15	
2. Main effects	FS	-303.9	138.7	0.04	0.04		-404.2	168.0	0.03	0.09	
	SDE	64.4	147.1	n.s.			188.0	178.7	n.s.		
3. Interaction	FS \times SDE	68.9	223.3	n.s.	-0.002		-245.4	266.0	n.s.	0.08	
2. Main effects	RFS	-48.1	161.3	n.s.	-0.18		-201.0	194.9	n.s.	-0.11	
	SDE	16.0	170.4	n.s.			173.2	206.0	n.s.		
3. Interaction	RFS \times SDE	101.0	211.3	n.s.	-0.23		-176.6	253.7	n.s.	-0.14	
2. Main effects	RCS	281.4	139.4	n.s.	0.07		201.3	189.3	n.s.	-0.11	
	IM	-189.6	137.4	n.s.			-137.5	186.5	n.s.		
3. Interaction	RCS \times IM	281.4	156.5	n.s.	0.16		201.1	225.8	n.s.	-0.12	
2. Main effects	FS	-270.7	141.8	n.s.	0.05		-361.4	177.9	n.s.	0.03	
	IM	-92.2	141.2	n.s.			-30.1	177.1	n.s.		

Step	Variable	Worship day alpha-amylase (AUC)				Non-worship day alpha-amylase (AUC)						
		Predictors		Model	Predictors		Model					
		β	SE	Sig.	adjusted r^2	β	SE	Sig.	adjusted r^2	Sig.		
3.	Interaction	FS × IM	167.6	254.8	n.s.	0.02	n.s.	154.6	321.4	n.s.	-0.01	n.s.
2.	Main effects	RFS	-5.2	156.5	n.s.	-0.14	n.s.	-124.8	196.4	n.s.	-0.15	n.s.
		IM	-151.8	154.9	n.s.			-81.1	194.3	n.s.		
3.	Interaction	RFS × IM	376.0	172.0	0.04	0.05	n.s.	306.7	231.8	n.s.	-0.11	n.s.
2.	Main effects	RCS	291.1	139.0	n.s.	0.05	n.s.	221.6	184.4	n.s.	-0.08	n.s.
		SDR	-172.9	138.3	n.s.			-190.8	183.6	n.s.		
3.	Interaction	RCS × SDR	285.4	1.14	n.s.	0.09	n.s.	85.7	302.4	n.s.	-0.13	n.s.
2.	Main effects	FS	-280.1	139.2	n.s.	0.04	n.s.	-353.3	172.7	n.s.	0.05	n.s.
		SDR	-51.6	140.0	n.s.			-67.1	173.7	n.s.		
3.	Interaction	FS × SDR	202.6	263.3	n.s.	0.02	n.s.	142.8	330.3	n.s.	0.01	n.s.
2.	Main effects	RFS	-10.7	156.4	n.s.	-0.15	n.s.	-111.9	193.0	n.s.	-0.13	n.s.
		SDR	-111.4	156.3	n.s.			-114.0	192.9	n.s.		
3.	Interaction	RFS × SDR	353.8	216.0	n.s.	-0.06	n.s.	231.1	279.8	n.s.	-0.15	n.s.

RCS, religious-commitment signaling; IM, impression management; FS, faith signaling; RFS, religious-faith signaling; SDR, self-deceptive enhancement; SDR, socially desirable responding.

commitment signaling and impression management on cortisol but minimal effect on alpha-amylase.

To understand why main effect and interaction associations with cortisol are in opposing directions, simple slopes were plotted at ± 1 SD. As Figure 1 illustrates for the worship and non-worship days, impression management is greater in participants with lower religious-commitment signaling, resulting in higher cortisol levels. The slightly higher cortisol levels among high RCS participants on the worship day are consistent with the higher activity levels characteristic of experiential worship on service days.

4 Discussion

We found that religious-commitment signaling was a significant influence on physiological stress response among these Pentecostal participants, as predicted, but only when moderated by impression management and primarily with regard to the cortisol biomarker. The influence seems to reduce stress, as expected, but the moderation effect reverses the direction of the association. This is in contrast to our simplistic prediction that socially desirable responding would amplify a benefit of religious-faith signaling. Instead, what seems to occur is that participants employ either religious-commitment signaling or impression management, resulting in lower cortisol. There were minimal

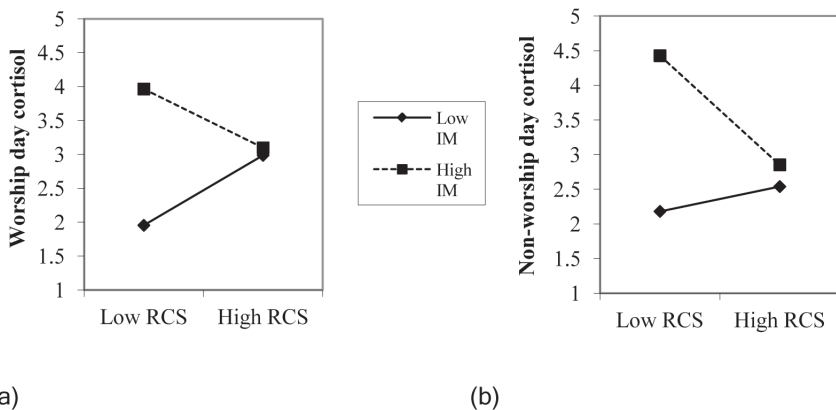


FIGURE 1 Moderating effect of impression management (IM) on the religious-commitment signaling (RCS)/worship day cortisol AUC (a) and RCS/non-worship day cortisol AUC (b) relationships (two-way interaction with continuous moderator controlling for sex and age, all variables standardized).

influences on alpha-amylase or of faith signaling, self-deceptive enhancement, or the full scales measuring religious-faith signaling or socially desirable responding.

While the relationship of religious-commitment signaling to impression management seems antagonistic, they may also be viewed as analogous. Impression management may compensate when religious signaling is low, given that the impression management scale has been found to reliably measure a communal form of socially desirable responding in the absence of an audience (Paulhus, 2002; Paulhus and Trapnell, 2008). Consistent with this, the impression management scale actually has a higher religious content, with 8 items that share substance with the Ten Commandments or the Sermon on the Mount compared to the 1 item with shared content in the self-deceptive enhancement scale (Sedikides and Gebauer, 2010).

Alternatively, impression management may be what Pentecostal newcomers do to impress others before they learn culturally-relative religious signaling. Based on ethnographic observations by the first author, newcomers often seemed more eager to make an impression than longer-standing supportive members, or what are sometimes derisively termed “Sunday Christians” (Williams, 1984). Many newcomers would make a point of introducing themselves and linger to fellowship with others but stop showing up after a few weeks or months, whereas supportive members were less effusive and maintained attendance once a week or so over a longer period. This distinction may be due to the value differences of religious signals.

Learning culturally-relative religious signaling is a process that takes time. Despite the initial obviousness of glossolalic behavior, which characterizes Pentecostal religion, consistent attendance and other signals have greater value in signaling commitment. Modes of religiosity theory (Whitehouse, 2004, 2008) suggest that “naturally-catchy,” imagistic, and doctrinal emphases vary in modern religions. Imagistic or revelatory aspects like glossolalia and arm-raising and other visible aspects of evangelical religion may help members participate when the more complex doctrinal system is difficult to understand. Furthermore, glossolalia may be compelling because of its striking nature. Minimally counterintuitive concepts, such as being possessed by another consciousness, are more memorable than normal logical ones (Boyer, 2001; Norenzayan et al., 2006), and therefore naturally-catchy (Whitehouse, 2004, 2008).

Observing counterintuitive concepts such as possession in others, especially among models of behavior that one respects, grants such concepts legitimacy and importance (Henrich, 2009) and may lead them to become

a disproportionate focus of worship. This was the case with the spouse of a member in this study, who focused on the obvious signals of possession at the expense of more complex aspects of commitment and was rebuked for her effort (Lynn, 2013). However, when such experiences are positive and shared with others, particularly the displacement of consciousness that characterizes possession trance, they are powerfully revelatory (Bourguignon, 1976) and create a positive feedback system in which individuals want more of what they've seen and experienced in the religious community. One participant described it as "a million times more intense than that overwhelming feeling of love you have when you look into your child's eyes." Therefore, individuals may be motivated to impress their commitment upon others if they have not yet internalized the doctrine. Several informants in this study spoke of their anxiety to receive the Holy Ghost and the extreme psychological and physical relief they experienced when it happened.

The association of impression management with reduced cortisol and moderating influence of impression management on religious-commitment signaling are important and novel findings. Follow-up research using *a priori* measures of religious-commitment signaling in a larger sample without a bias toward those displaying the highest rates of religious-faith signaling would bolster our conclusions. The variation between stress and arousal outcomes and the lower stress exhibited in participants with lower impression management but higher religious-commitment signaling support previous findings about the distinctiveness of sCORT and sAA as biomarkers of stress and the influence of Pentecostal religiosity and glossolalia on cortisol (Lynn et al., 2010, 2011). Additionally, our findings are consistent with others regarding the effectiveness of religious-commitment signaling in context (Sosis and Ruffle, 2003; Soler, 2008, 2012). As such, these findings contribute significantly to the cognitive science of religion by demonstrating that religious signaling of commitment is moderated by socially desirable responding with biological implications. Future research can extend this model through application to other religious traditions.

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References

- Adam, E.K. and Kumari, M. (2009). Assessing salivary cortisol in large-scale, epidemiological research. *Psychoneuroendocrinology* 34, 1423-1436.
- Alcorta, C. and Sosis, R. (2005). Ritual, emotion, and sacred symbols. *Human Nature* 16, 323-359.
- Bartlett, M.S. (1954). A note on the multiplying factors for various χ^2 approximations. *Journal of the Royal Statistical Society. Series B (Methodological)* 16, 296-298.
- Benson, P.L., Donahue, M.J. and Erickson, J.A. (1993). The faith maturity scale: Conceptualization, measurement, and empirical validation. In Lynn, M.L. and Moberg, D.O. (Eds), *Research in the social scientific study of religion*, pp. 1-26. JAI Press, Greenwich, CT.
- Boivin, M.J. (1999). Religiosity measure (review). In Hill, P.C. and Hood, R.W. (Eds), *Measures of religiosity*, pp. 307-310. Religious Education Press, Birmingham, AL.
- Bourguignon, E. (1976). *Possession*. Waveland Press, Prospect Heights, IL.
- Boyer, P. (2001). *Religion explained: The evolutionary origins of religious thought*. Basic Books, New York, NY.
- Bulbulia, J. (2008). Free love: Religious solidarity on the cheap. In Bulbulia, J., Sosis, R., Harris, E., Genet, R., Genet, C. and Wyman, K. (Eds), *The evolution of religion: Studies, theories, and critiques*, pp. 153-160. Collins Foundation Press, Santa Margarita, CA.
- Bulbulia, J. and Sosis, R. (2011). Signalling theory and the evolution of religious cooperation. *Religion* 41, 363-388.
- Cattell, R.B. (1966). The scree test for the number of factors. *Multivariate Behavioral Research* 1, 245-276.
- Cleary, E.L. (1997). Introduction: Pentecostals, prominence, and politics. In Cleary, E.L. and Stewart-Gambino, H.W. (Eds), *Power, politics, and Pentecostals in Latin America*, pp. 1-24. Westview Press, Boulder, CO.
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Lawrence Erlbaum Associates, Hillsdale, NJ.

- Cox, H.G. (1995). *Fire from heaven: The rise of Pentecostal spirituality and the reshaping of religion in the twenty-first century*. Da Capo Press, Cambridge, MA.
- Cronk, L. (2005). The application of animal signaling theory to human phenomena: Some thoughts and clarifications. *Social Science Information* 44, 603-620.
- . (1994). Evolutionary theories of morality and the manipulative use of signals. *Zygon* 29, 81-101.
- Dawson, J.F. (2014). Moderation in management research: What, why, when, and how. *Journal of Business and Psychology* 29, 1-19.
- Ellison, C.G. and Hummer, R.A. (2010). *Religion, families, and health: Population-based research in the United States*. Rutgers University Press, New Brunswick, NJ.
- Eriksson, K. and Funcke, A. (2015). Humble self-enhancement: Religiosity and the better-than-average effect. *Social Psychological and Personality Science* 5, 76-83.
- Frank, R.H. (1988). *Passions within reason: The strategic role of emotions*. W.W. Norton, New York, NY.
- . (1993). The strategic role of the emotions: Reconciling over- and undersocialized accounts of behavior. *Rationality and Society* 5, 160-184.
- Glucklich, A. (2001). *Sacred pain*. Oxford University Press, New York, NY.
- Hellhammer, D.H., Wüst, S. and Kudielka, B.M. (2009). Salivary cortisol as a biomarker in stress research. *Psychoneuroendocrinology* 34, 163-171.
- Henrich, J. (2009). The evolution of costly displays, cooperation and religion: Credibility enhancing displays and their implications for cultural evolution. *Evolution and Human Behavior* 30, 244-260.
- Hine, V.H. (1969). Pentecostal glossolalia: Toward a functionalist interpretation. *Journal for the Scientific Study of Religion* 8, 211-226.
- Hirschleifer, J. (1987). On the emotions as guarantors of threats and promises. In Dupre, J. (Ed.), *The latest on the best: Essays in evolution and optimality*, pp. 307-326. MIT Press, Cambridge, MA.
- Irons, W. (2001). Religion as a hard-to-fake sign of commitment. In Nesse, R.M. (Ed.), *Evolution and the capacity for commitment*, pp. 292-309. Russell Sage Foundation, New York, NY.
- . (2008). Why people believe (what other people see as) crazy ideas. In Bulbulia, J., Sosis, R., Harris, E., Genet, R., Genet, C. and Wyman, K. (Eds), *The evolution of religion: Studies, theories, and critiques*, pp. 51-57. Collins Foundation Press, Santa Margarita, CA.
- Johnson, D.D.P. (2004). *Overconfidence and war: The havoc and glory of positive illusions*. Harvard University Press, Cambridge, MA.
- Kaiser, H.F. (1970). A second generation little jiffy. *Psychometrika* 35, 401-415.
- . (1974). An index of factorial simplicity. *Psychometrika* 39, 31-36.
- Kay, W.K. and Francis, L.J. (1995). Personality, mental health and glossolalia. *Pneuma: The Journal of the Society for Pentecostal Studies* 17, 253-263.

- Kirschbaum, C. and Hellhammer, D.H. (2007). Salivary cortisol. In Fink, G., McEwen, B., de Kloet, E.R., Rubin, R., Chrousos, G., Steptoe, A., Rose, N., Craig, I. and Feuerstein, G. (Eds), *Encyclopedia of stress*, pp. 405-409. Academic Press, New York, NY.
- Koenig, H.G. (2009). Research on religion, spirituality, and mental health: A review. *Canadian Journal of Psychiatry. Revue Canadienne de Psychiatrie* 54, 283-291.
- Lovallo, W.R. and Thomas, T.L. (2000). Stress hormones in psychophysiological research: Emotional, behavioral, and cognitive implications. In Cacioppo, T.J., Tassinari, L.G. and Bernston, G.G. (Eds), *Handbook of psychophysiology*, pp. 342-367. Cambridge University Press, New York, NY.
- Lynn, C.D. (2013). "The wrong Holy Ghost": Discerning the Apostolic gift of discernment using a signaling and systems theoretical approach. *Ethos* 41, 223-247.
- Lynn, C.D., Paris, J.J., Frye, C.A. and Schell, L.M. (2010). Salivary alpha-amylase and cortisol among Pentecostals on a worship and nonworship day. *American Journal of Human Biology* 22, 819-822.
- . (2011). Glossolalia is associated with differences in biomarkers of stress and arousal among Apostolic Pentecostals. *Religion, Brain and Behavior* 1, 173-191.
- Nater, U.M. and Rohleder, N. (2009). Salivary alpha-amylase as a non-invasive biomarker for the sympathetic nervous system: Current state of research. *Psychoneuroendocrinology* 34, 486-496.
- Nater, U.M., Rohleder, N., Schlotz, W., Ehlert, U. and Kirschbaum, C. (2007). Determinants of the diurnal course of salivary alpha-amylase. *Psychoneuroendocrinology* 32, 392-401.
- Norenzayan, A., Atran, S., Faulkner, J. and Schaller, M. (2006). Memory and mystery: The cultural selection of minimally counterintuitive narratives. *Cognitive Science* 30, 531-553.
- Paulhus, D.L. (1991). Measurement and control of response bias. In Robinson, J.P., Shaver, P.R. and Wrightsman, L.S. (Eds), *Measures of personality and social psychological attitudes*, pp. 17-59. Academic Press, San Diego, CA.
- . (2002). Socially desirable responding: The evolution of a construct. In Braun, H.I., Jackson, D.N. and Wiley, D.E. (Eds), *The role of constructs in psychological and educational measurement*, pp. 51-69. Lawrence Erlbaum Associates, Mahwah, NJ.
- Paulhus, D.L. and Trapnell, P.D. (2008). Self-presentation of personality: An agency-communion framework. In John, O.P., Robins, R.W. and Pervin, L.A. (Eds), *Handbook of personality psychology: Theory and research*, pp. 492-517. Guilford Press, New York, NY.
- Richardson, J.T. (1973). Psychological interpretations of glossolalia: A reexamination of research. *Journal for the Scientific Study of Religion* 12, 199-207.
- Rohrbaugh, J. and Jessor, R. (1975). Religiosity in youth: A personal control against deviant behavior. *Journal of Personality* 43, 136-155.
- Sapolsky, R.M. (2002). Endocrinology of the stress-response. In Becker, J.B., Breedlove, S.M., Crews, D. and McCarthy, M.M. (Eds), *Behavioral endocrinology*, pp. 409-451. MIT Press, Cambridge, MA.

- Schelling, T. (1960). *The strategy of conflict*. Harvard University Press, Cambridge, MA.
- Sedikides, C. and Gebauer, J.E. (2010). Religiosity as self-enhancement: A meta-analysis of the relation between socially desirable responding and religiosity. *Personality and Social Psychology Review* 14, 17-36.
- Simpson, J.J. (2012). *Addressing the religious free-rider problem via religious consumption signaling and religious capital accumulation*. Master of Arts Thesis, Colorado State University, Boulder, CO.
- Soler, M. (2008). Commitment costs and cooperation: Evidence from Candomblé, and Afro-Brazilian religion. In Bulbulia, J., Sosis, R., Harris, E., Genet, R., Genet, C. and Wyman, K. (Eds), *The evolution of religion: Studies, theories, and critiques*, pp. 167-174. Collins Foundation Press, Santa Margarita, CA.
- Soler, M. (2012). Costly signaling, ritual and cooperation: Evidence from Candomblé, an Afro-Brazilian religion, *Evolution and Human Behavior* 33, 346-356.
- Sosis, R. (2004). The adaptive value of religious ritual. *American Scientist* 92, 166-172.
- . (2006). Religious behaviors, badges, and bans: Signaling theory and the evolution of religion. In McNamara, P. and Ellens, J.H. (Eds), *Where God and science meet: How brain and evolutionary studies alter our understanding of religion, volume 1: Evolution, genes, and the religious brain*, pp. 61-86. Praeger, Westport, CT.
- Sosis, R. and Alcorta, C.S. (2003). Signaling, solidarity, and the sacred: The evolution of religious behavior. *Evolutionary Anthropology: Issues, News, and Reviews* 12, 274.
- Sosis, R. and Bressler, E.R. (2003). Cooperation and commune longevity: A test of the costly signaling theory of religion. *Cross-Cultural Research* 37, 211-239.
- Sosis, R. and Ruffle, B.J. (2003). Religious ritual and cooperation: Testing for a relationship on Israeli religious and secular kibbutzim. *Current Anthropology* 44, 713-722.
- Sosis, R., Kress, H.C. and Boster, J.S. (2007). Scars for war: Evaluating alternative signaling explanations for cross-cultural variance in ritual costs. *Evolution and Human Behavior* 28, 234-247.
- Spence, M. (1973). Job market signaling. *The Quarterly Journal of Economics* 87, 355-374.
- Stöber, J., Dette, D.E. and Musch, J. (2002). Comparing continuous and dichotomous scoring of the balanced inventory of desirable responding. *Journal of Personality Assessment* 78, 370-389.
- Taylor, S.E. and Armor, D.A. (1996). Positive illusions and coping with adversity. *Journal of Personality* 64, 873-898.
- Taylor, S.E. and Brown, J.D. (1994). Positive illusions and well-being revisited: Separating fact from fiction. *Psychological Bulletin* 116, 21-27.
- Thurstone, L.L. (1947). *Multiple factor analysis*. University of Chicago Press, Chicago, IL.
- Tisdale, T.C. (1999). Faith maturity scale (review). In Hill, P.C. and Hood, R.W. (Eds), *Measures of religiosity*, pp. 171-174. Religious Education Press, Birmingham, AL.
- Trimble, D.E. (1997). The religious orientation scale: Review and meta-analysis of social desirability effects. *Educational and Psychological Measurement* 57, 970-986.

- Tuzin, D.F. (1982). Ritual violence among the Iahita Arapesh: The dynamics of moral and religious uncertainty. In Herdt, G.H. (Ed.), *Rituals of manhood: Male initiation in Papua New Guinea*, pp. 321-355. University of California Press, Berkeley, CA.
- Uchino, B. (2006). Social support and health: A review of physiological processes potentially underlying links to disease outcomes. *Journal of Behavioral Medicine* 29, 377-387.
- Veblen, T. (2007 [1899]). *The theory of the leisure class*. Oxford University Press, Oxford.
- Whitehouse, H. (2004). *Modes of religiosity: A cognitive theory of religious transmission*. AltaMira Press, Walnut Creek, CA.
- . (2008). Cognitive evolution and religion: Cognition and religious evolution. In Bulbulia, J., Sosis, R., Harris, E., Genet, R., Genet, C. and Wyman, K. (Eds), *The evolution of religion: Studies, theories, and critiques*, pp. 31-42. Collins Foundation Press, Santa Margarita, CA.
- Williams, M.D. (1984). *Community in a black Pentecostal church: An anthropological study*. Waveland Press, Prospect Heights, IL.