Contagious yawning, empathy, and their relation to pro-social behavior

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February 2018

Franzen, A., Mader, S., & Winter, F. (2018, May 17). Contagious Yawning, Empathy, and Their Relation to Prosocial Behavior. Journal of Experimental Psychology: General. Advance online publication. http://dx.doi.org/10.1037/xge0000422

Abstract

Humans express facial mimicry across a variety of actions. This paper explores a very distinct example, contagious yawning, and the links to empathy and pro-social behavior. Prior studies suggest that there is a positive link between empathy and the susceptibility to contagious yawning. However, the existing evidence is sparse and contradictory. We present results from two laboratory studies conducted with 171 (study 1) and 333 (study 2) student volunteers. Subjects were video-recorded while watching muted videos of individuals yawning, scratching, or laughing. Empathy was measured using the Interpersonal Reactivity Index. While subjects imitated all facial expressions to large extents, our studies show that only contagious yawning was related to empathy. Subjects who yawned in response to observing others yawn exhibited higher empathy values by half a standard deviation. However, we found no evidence that the susceptibility to contagious yawning is directly related to pro-social behavior.

Keywords: contagious yawning, empathy, pro-social behavior, social coordination, mimicry

1. Introduction

Humans are social beings. We are highly skilled in interpreting the facial expressions and gestures of other humans and in responding to the signals, expectations and behaviors encoded in these actions. Some forms of emotional and behavioral imitation appear unconsciously and within milliseconds (e.g. Chartrand and Bargh 1999, Dimberg et al. 2000). Other reactions are more conscious and context dependent (see Hess and Fischer 2013 for a recent review). Both strands of the literature suggest that mimicry, be it conscious or unconscious, facilitates social cohesion and coordination in groups (e.g. Lakin et al. 2003). The existing evidence suggests that mimicry works in two ways: First, the mimickee infers from the imitation of his behavior or gestures that others understand his intentions or emotions. Second, the mimicker enhances his empathy with the person he imitates. Thus, Stel et al. (2008) showed that subjects who were instructed to mimic others also have higher levels of empathy for the imitated person. Hence, mimicking others can elevate empathy, which in turn increases pro-social behavior even to others not related to the mimicking.

Also the relation between empathy and pro-social behavior has been much discussed in the literature (Batson 1991, Batson and Moran 1999, De Waal 2012, Eisenberg and Miller 1987, Galinsky et al. 2008, Stocks et al. 2009). Some authors suggest that empathy is an unpleasant emotion. One way of reducing it is to either escape situations in which empathy emerges or to help those in need. This hypothesis has been termed the aversive-arousal reduction hypothesis (AARH) (Batson 1991). According to the AARH hypothesis pro-social behavior is basically a selfish response. An alternative mechanism is that empathy highlights an altruistic perspective. So far most evidence supports this empathy-altruism hypothesis (EAH) (Stocks et al. 2009, Doris and Stitch 2007, Nichols 2004).

In this paper we focus on a very distinct and peculiar phenomenon of mimicry, namely on the contagiousness of yawning. Humans, like most vertebrates, yawn occasionally. The existing evidence suggests that it is induced by sleepiness. Yawning increases the oxygen content of the blood and lowers the brain temperature, functioning as a wake-up call (Provine 2005, Gallup and Gallup 2007, 2008, Guggisberg et al. 2011, Zilli et al. 2008). However, yawning can also be contagious. Former studies suggest that about 40% to 60% of humans are susceptible to contagious yawning (e.g. Gallup et al. 2016), and there is also evidence that it is contagious among some animals, like chimpanzees, dogs and wolves (e.g. Romero et al. 2013, Romero et al. 2014).

Moreover, some studies suggest that the susceptibility of contagious yawning is linked to the degree of empathy (Lehmann 1979, Norscia et al 2016, Palagi et al. 2009, Provine 1986, 2005). For instance, Platek et al. (2003) found that individuals who are more sensitive to contagious yawning also recognize social faux-pas in written reports better than subjects who are not susceptible to it. Yawning is also more contagious among individuals with close social ties, as compared to strangers (Norscia et al 2016a, Norscia and Palagi 2011, Palagi et al. 2014). Moreover, Haker and Roessler (2009) find that individuals with schizophrenic disorders are less sensitive to contagious yawning and also display lower empathy values compared to healthy individuals. Further evidence stems from studies in neuroscience that use functional magnetic resonance imaging (fMRI). These results suggest that the urge to yawn when observing others yawning is related to neural activity in those areas of the brain that are involved in assessing self-referent information (Arnott et al. 2009, Brown et al. 2017, Cooper et al. 2012, Haker et al. 2013, Platek et al. 2005).

To sum up, research so far suggests that asking individuals to imitate others elevates their empathy, and empathy in turn increases pro-social behavior. In this paper we investigate a slightly different question. We study the link of contagious yawning and empathy if researchers do not actively encourage the mimicry. Hence, we investigate if the susceptibility of contagious yawning is also an indicator of individuals' base line empathy level. Some existing evidence on contagious yawning suggests this link. However, other studies show counterevidence. Particularly, a study by Bartholomew and Cirulli (2014) using 328 subjects finds no evidence that contagious yawning is related to empathy. Besides its comparatively large sample the study by Bartholomew and Cirulli (2014) has the advantage of measuring empathy directly via the Interpersonal Reactivity Index (IRI) while studies reporting positive evidence rely on indirect measures such as the faux-pas test or the auxiliary assumption that empathy is higher among closer social ties.

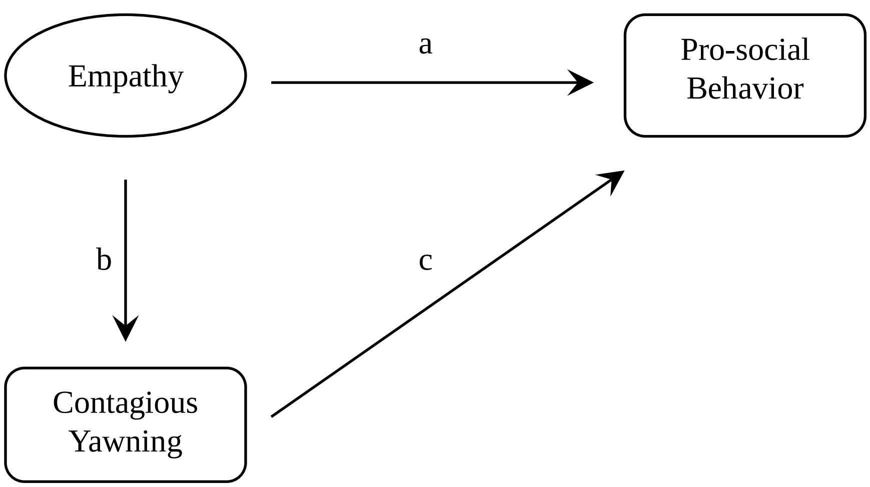
But Bartholomew and Cirulli's (2014) study also has some disadvantages. First, subjects had to self-report whether they yawned or not. Measuring yawning by self-report has the disadvantage of leaving the measurement to the subjects and their interpretation, and thus, withdraws it from the control of the experimenter. Second, they informed subjects of the phenomenon of contagious yawning before they participated in the study, which may have stimulated the social desirability of contagious yawning. Yawning was reported by 67% of their subjects, which is a higher incidence of yawning than reported in other studies. The high incidence could have obscured the difference between yawners and non-yawners with respect to empathy. Furthermore, Bartholomew and Cirulli (2014) do not use any control group in their study. Therefore, it remains unclear what the rate of yawning would have been if subjects would have watched other stimulus videos of non-yawning faces. This makes the distinction between yawning that occurs spontaneously and yawning that occurs due to contagion impossible.

Taken together, the empirical evidence on whether contagious yawning is related to empathy is still unclear and the existing evidence contradictory (e.g. Massen and Gallup 2017). Studies that find positive evidence did not employ direct measurements of empathy (e.g. by using the IRI) and the study that finds no evidence (Bartholomew and Cirulli 2014) uses a weak measure of the occurrence of contagious yawning. To gain further insight into the phenomenon of contagious yawning and its relation to empathy we conducted two studies with large samples of healthy volunteers. Study 1 was conducted very similarly to the Bartholomew and Cirulli study (2014). However, we videotaped subjects while they were watching the stimulus videos and coded the occurrence of yawning from these videos. Since prior studies propose that empathy is an important prerequisite of altruism and pro-social behavior (Batson and Moran

1999, De Waal 2012, De Waal and Preston 2017, Eisenberg and Miller 1987, Galinsky et al. 2008, Stocks et al. 2009) we extend the existing literature on contagious yawning by also investigating whether it is directly related to pro-social behavior. In study 1 the test consisted of a dictator game in which subjects had the opportunity to donate some (or all) of their endowment to an anonymous recipient. Since study 1 also did not involve a control group we conducted a second study in which participants were randomized into a treatment group and a control group. In the treatment group subjects watched videos of laughing faces, people scratching or touching their face or hair, and yawning faces. In the control group subjects only watched laughing and scratching subjects. This experimental procedure allows us to determine the natural occurrence of spontaneous yawning in comparison to contagious yawning. Moreover, it also allows us to test whether other forms of mimicry (scratching and laughing) are related to empathy. We also measured pro-social behavior in study 2 by giving subjects the opportunity to donate some (or all) of their experimental payment to a charitable organization.

Summing up, we investigate three hypotheses (see Figure 1): Hypothesis A postulates that empathy is positively related to pro-social behavior. Hypothesis B suggests that empathy varies among individuals and that the susceptibility of contagious yawning is an indicator of empathy. Hypothesis C suggests that those who show contagious yawning also show more likely pro-social behavior.

Figure 1: Summary of the hypotheses



Note: (a) postulates that empathy is positively related to pro-social behavior; (b) suggests that empathetic individuals are susceptible to contagious yawning, and that it is an indicator of empathy; (c) suggests that those who show contagious yawning are also more likely to show pro-social behavior.

The remainder of the article proceeds in five sections. Section two describes the methods of study 1, and section three reports the results. Section four discusses the limitations of study 1 and describes the methods of study 2, which responds to the limitations of study 1, and extends the existing evidence. Specifically, study 2 investigates if other forms of facial mimicry are also indicators of empathy. Section five reports the results of study 2. Finally, the results of both studies are summarized and discussed in the last section.

2. Study 1, methods

Study 1 was conducted to replicate the findings of Bartholomew and Cirulli (2014). We recruited 191 students from various academic disciplines of the University of Bern between March 24th and April 29th, 2015, conducting 22 experimental sessions with 5-10 participants each in the university's lab. Upon arrival in the lab, subjects were seated in cubicles in front of computers, which were equipped with a video camera (pictures of the lab are included in the online supplement, see Figure S1). Subjects first played a dictator game via paper and pencil to measure pro-social behavior (Eckel and Grossman 1996, Klimecki et al. 2016). Subjects were instructed that they receive 10 Swiss Francs (about US$ 10), which they can share in any way they want with another person randomly drawn from the university's student population. They were told that the identity of the recipient would not be disclosed to them. Since donation behavior is heavily influenced by subjects' anonymity (Franzen and Pointner 2012), we took great care that the experimental staff could not associate any donated amount to a specific subject (see supplement for a detailed description of the instructions).

After completion of the dictator game, the experimental staff switched on the computers, the cameras, and attached a pulse meter (Contec™CMS60C) to subjects' forefingers. We then showed a three-minute video of yawning faces of different individuals of various ages and both sexes to the subjects. Subjects were video-recorded while watching this stimulus video. The videos were later coded according to whether subjects yawned while watching the stimulus video, how many times they yawned and at which time(s) during the experiment yawning occurred. The stimulus video was followed by an online questionnaire, which contained a short version (16 items) of the Interpersonal Reactivity Index (IRI) (Davis 1983, Paulus 2009) to measure empathy as well as a few questions on individuals' energy level and some socio-demographic characteristics of the participants.

Since yawning occurs not only by contagion, but also because of sleepiness (Provine 2005), we tried to measure subjects' sleepiness by using the pulse meter. Prior studies have shown that yawning due to sleepiness is accompanied by a falling pulse rate (Carrington et al. 2005, Corey et al. 2011). Additionally, we measured sleepiness by using the Circadian Energy Scale (CIRENS) (Ottoni 2011).

Before starting the camera and applying the pulse meter, a detailed description of both appliances was provided on the screen. In particular, participants were informed about the process of data collection and measures to keep results anonymous. Subjects explicitly had to consent to being video-recorded by clicking an “accept” button on the computer screen. Six out of the 191 participants did not agree to being video-recorded and left the experiment. A further 14 faces were not fully visible in the videos, making the coding of whether yawning occurred or not impossible. This left us with 171 valid cases for analysis. Furthermore, the pulse meter did not work correctly in every case and in one session the data was lost due to technical difficulties. Hence, study 1 has 128 complete cases for those analyses that take pulse rates into account.[1]

3. Results of Study 1

Sixty-five of the 171 subjects in study 1 were male (38%) and the average age of participants was 23.8 years (range 18 to 37 years, SD = 3.08). Table 1 displays the sixteen items of the IRI, which measure empathy. Each item contains five answer categories ranging from “never” to “always”. Consistent with former research, an exploratory factor component analysis reveals that the 16 items fall into four sub-dimensions referred to as “perspective taking”, “fantasy”, “empathetic concern” and “personal distress”. The additive index of all 16 items reaches a high level of reliability, as indicated by a Cronbach’s alpha of 0.77. The sub-dimension “personal distress” is sometimes excluded from the analysis, since it measures self-management rather than empathy. Our results are robust if this dimension is excluded (see Table S1 and Figure S2 in the supplement).

Twenty-four per cent of our subjects yawned at least once while watching the stimulus video. Those who did yawn have a mean value of 0.45 on the standardized IRI (z-standardized, $M = 0$, $SD = 1$), as compared to -0.14 for subjects who did not yawn. This difference is more than half a standard deviation on the empathy scale and is highly statistically significant ($t(169) = 3.43$, $p < 0.001$, two-sided t-test). A comparison of the distribution of those who yawned and those who did not is visualized in Figure 2A. Since yawning can also occur spontaneously due to subjects’ sleepiness or possible boredom during the experiment (Gallup and Gallup 2007, 2008, Guggisberg et al. 2011, Provine 2005, Zilli et al. 2008), we controlled for sleepiness by measuring the subjects’ pulse rate and general activity level via the Circadian Energy Scale (CIRENS) (Ottoni et al. 2011). The average pulse rate of subjects who did yawn was 74.5 beats per minute, and 76.7 for those who did not. This difference is not statistically significant ($t(126) = 0.65$, $p = 0.51$, two-sided t-test), which is in line with the assumption that the yawning observed was induced by contagion and not by sleepiness (see also Figure S3 in the supplement).

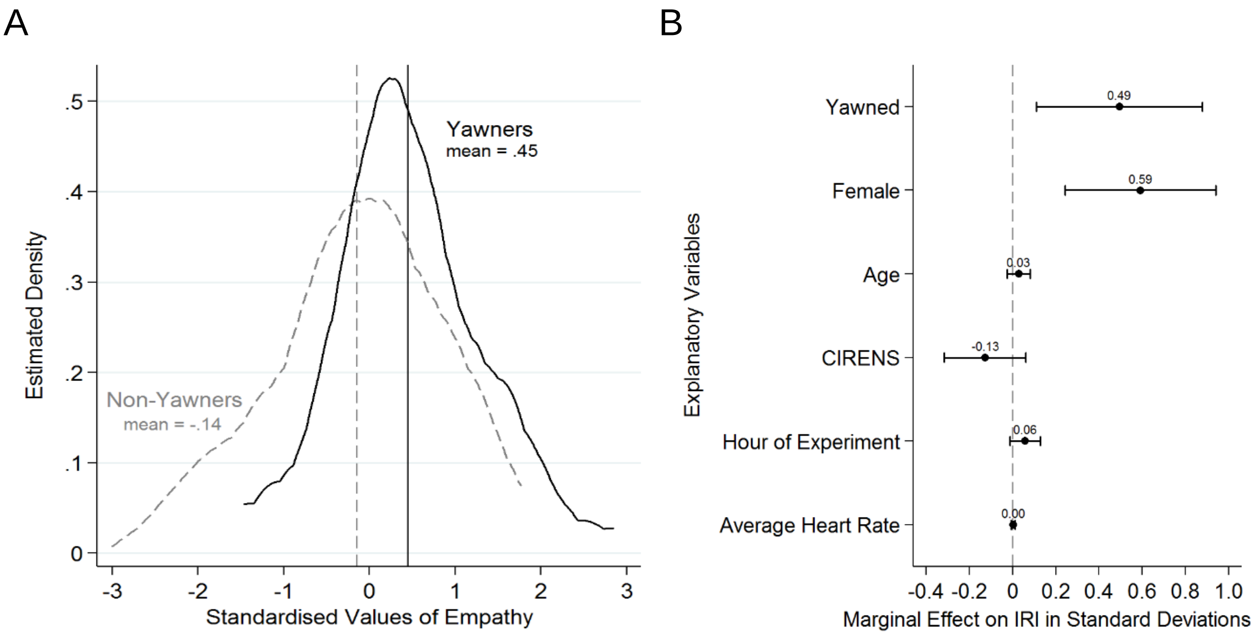
[1] The ethical standard of both experiments was approved by the Faculty of Business Administration, Economics and Social Sciences of the University of Bern and the experiments were strictly carried out in accordance with the guidelines outlined by the Declaration of Helsinki.

Table 1: The four dimensions of the Interpersonal Reactivity Index (IRI) used in the experiment.

			Study 1	Study 2
Perspective Taking	(1)	I try to look at everybody's side of a disagreement before I make a decision.	0.80	0.75
	(2)	I believe that there are two sides to every question and try to look at them both.	0.76	0.75
	(3)	When I am upset with someone, I usually try to put myself in his shoes for a while.	0.54	0.65
	(4)	Before criticizing somebody, I try to imagine how I would feel if I were in their place.	0.65	0.73
Fantasy	(5)	I really get involved with the feelings of the characters in a novel.	0.65	0.61
	(6)	After seeing a play or movie, I have felt as though I were one of the characters.	0.70	0.74
	(7)	When I watch a good movie, I can very easily put myself in the place of a leading character.	0.84	0.72
	(8)	When I am reading an interesting story or novel, I imagine how I would feel if the events in the story were happening to me.	0.65	0.73
Empathetic Concern	(9)	I often have tender, concerned feelings for people less fortunate than me.	0.72	0.74
	(10)	When I see someone being taken advantage of, I feel kind of protective towards them.	0.69	0.58
	(11)	I am often quite touched by things that I see happen.	0.52	0.61
	(12)	I would describe myself as a rather soft-hearted person.	0.52	0.68
Personal Distress	(13)	In emergency situations, I feel apprehensive and ill-at-ease.	0.67	0.70
	(14)	I sometimes feel helpless when I am in the middle of a very emotional situation.	0.73	0.80
	(15)	Being in a tense emotional situation scares me.	0.79	0.78
	(16)	I tend to lose control during emergencies.	0.42	0.41
		N	171	333
		Cronbach's α	0.77	0.73

Note: Numbers indicate factor loadings after varimax rotated exploratory component factor analysis in study 1 and 2.

Figure 2: The Distribution of Empathy and Predictors of Empathy in Study 1



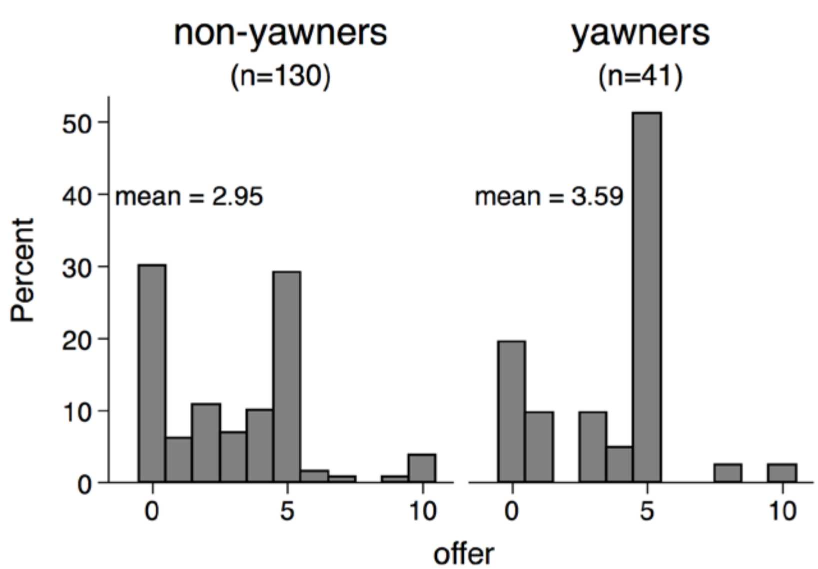
Notes: The plot in panel A shows Kernel density estimates (n = 171) of the z-standardized distribution of empathy among individuals not showing contagious yawning (dashed grey curve) (n = 130) and individuals who did show contagious yawning (solid black curve) (n = 41) as measured by the Interpersonal Reactivity Index (IRI). Non-yawners had .59 standard deviations lower empathy values than did yawners (-.14 vs. .45), suggesting that contagious yawning is a visual indicator of empathy. This difference in means is statistically significant $t(169)$ = 3.43, p < .001,). Panel B represents the coefficient plot of the OLS regression of the z-standardized IRI on its predictors and contagious yawning (see Model 3 in Table S1 in the supplement, n = 128, adjusted R^2 = .13) including the 95 % confidence intervals. CIRENS = Circadian Energy Scale.

The CIRENS was recoded in such a way that it measured the general energy level of subjects in the morning for those who also participated in morning sessions, and accordingly the general energy level in the afternoon or evening for those who participated in afternoon or evening sessions. Furthermore, we took the subjects' age and sex into consideration. We then analyzed the variance of empathy via a multiple OLS regression with the IRI as the dependent variable controlling for the various indicators of sleepiness. The results of this analysis are displayed in Figure 2B. They reveal that subjects who yawned still have 0.49 standard deviations higher empathy values as measured by IRI even controlling for the indicators of sleepiness (pulse rate, CIRENS values, time of day the experiment took place). None of these indicators has an effect on the empathy score. Further analyses reveals that all sub-dimensions of the IRI are positively related to contagious yawning. However, the association is statistically not significant with respect to perspective taking and personal distress (see Table S2 in the supplement). Our results also suggest that females have higher empathy. The OLS coefficient indicates that females are on average 0.59 standard deviations higher on the IRI as compared to males, which mirrors the results of other studies (e.g. Chan and Tseng 2017, Norscia et al. 2016a, Willer et al. 2015).

Next, we turn to the results concerning the donation behavior in the dictator game. Yawners donated on average 3.59 of the 10 Swiss Francs to the anonymous recipient, as compared to non-yawners, who donated 2.95 Francs. This difference is in the expected direction but not statistically significant ($t(169) = 1.45$, $p = 0.15$, two-sided t-test, Mann-Whitney U-test $z = 1.87$, $p = 0.06$, see Figure 3).

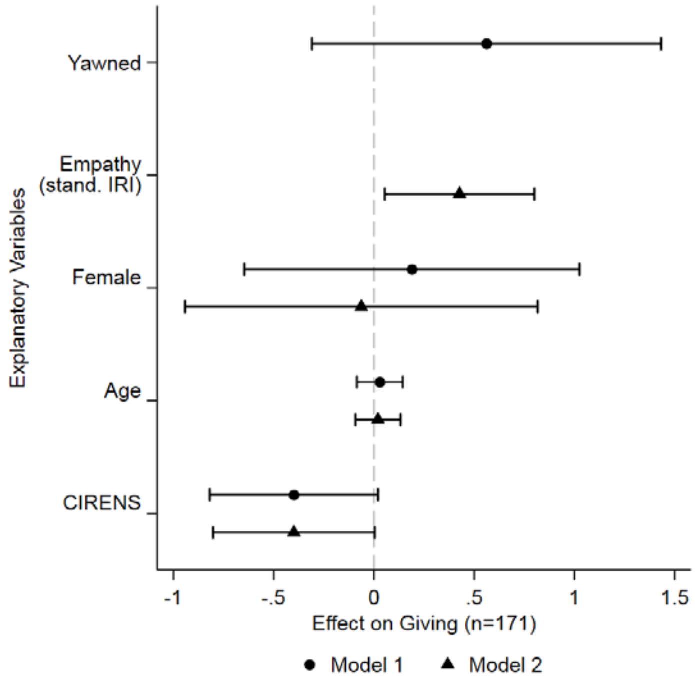
This result is also confirmed by a multiple OLS regression of the amount donated on contagious yawning including other covariates such as subjects' sex, age, IRI, and the measurement of sleepiness. The results of the OLS regression (Figure 4) show that empathy as measured by the IRI is related to giving in the dictator game, confirming previous findings (e.g. Klimecki et al. 2016). This is also true for the sub-components of the IRI except for personal distress (see Table S4 in the supplement). However, contagious yawning is not directly linked to participants' donation in the dictator game. Hence, our data does not support the notion that the susceptibility to contagious yawning is directly related to pro-social behavior (Hypothesis C).

Figure 3: Donation in the dictator game by yawners and non-yawners



Notes: The Figure displays the offers in Swiss Francs made by subjects not showing contagious yawning (left side), and those showing contagious yawning (right side). Yawners gave slightly more than did non-yawners; however, this difference is not statistically significant.

Figure 4: OLS regression of the donation behavior in the dictator game.



Notes: The figure displays the coefficient plot of the OLS regression of donation behavior in the dictator game on its predictors including the 95% confidence intervals (see also Table S3 in the supplement).

4. Study 2, methods

Study one has some limitations. Like the study by Bartholomew and Cirulli (2014) it did not involve a control group. Hence, it is unclear if the yawning observed was elicited by contagion or was spontaneous and would have happened even if the subjects had not watched yawning faces. Furthermore, study one raises the question whether contagious yawning is unique or whether the mimicry of other facial expressions is also related to empathy. To answer these questions, we conducted the second study.

Study 2 was conducted with 363 student volunteers from various disciplines of the University of Bern in 46 sessions with 5 to 10 participants each one year later (March 22nd to April 14th, 2016). There are four important differences to study 1. First, subjects were randomized into a treatment group and a control group. In the treatment group subjects first watched videos of individuals of different sexes and ages touching their face or hair (e.g. scratching their nose) for 1.5 minutes, followed by a video sequence of 1.5 minutes of laughing faces and finally a three-minute video of yawning individuals. We integrated the scratching and laughing faces into the treatment group to better conceal the purpose of the study from subjects. In the control group subjects only watched individuals scratching their face for 2 minutes and laughing for 4 minutes but no yawning individuals.[2] We could also have split the exposure time to 3 minutes each in the control group. However, as it turned out, the exposure times of scratching and laughing faces did not make a difference in terms of imitation rates. In both groups, the videos lasted for 6 minutes.

Second, instead of the dictator game, pro-social behavior was measured by offering subjects the opportunity to donate some (or all) of the experimental payment to a charitable organization at the end of the experiment. Donating money in a dictator game to an anonymous person is relatively abstract, particularly if it is unknown whether the recipient is in need or not. There is debate around whether giving in the dictator game measures pro-social behavior or instead fairness or altruism. The latter are related to pro-social behavior but not completely identical. To employ an alternative measure of pro-social behavior, subjects in study 2 were given a list of the most well-known charitable organizations and were given the opportunity to donate some (or all) of the payment of 20 Swiss Francs (about US$ 20) they received for participating in the experiment.

Third, we measured subjects' tiredness by directly asking how tired they felt during the experiment (measured on a scale from 0 "not at all tired" to 10 "very tired"). Forth, we also included a measure of social desirability into the questionnaire. Subjects were given a list with four tourist sites in the city of Bern and a list with four publicly known personalities. One out of the four answers in each list contained a fictional name. Subjects that answered that they knew the fictional person or the fictional tourist site could be more susceptible to social desirability, which might affect the susceptibility to contagious yawning, and also the measurement of empathy by the IRI. Hence, social desirability could distort the results.

5. Results of Study 2

We recruited 363 subjects for study 2. However, thirty faces were not fully visible in the videos, leaving us with 333 valid cases.[3] Overall, 71.2% (237) of subjects were female and 28.8% (96) male. Subjects' age ranged from 19 to 34 years with a mean of 23.6 (SD = 2.91). The randomization was done via the software *z-tree* (Fischbacher 2007), which was also used for the questionnaire. It assigned 183 subjects into the treatment group and 150 into the control group. The proportion of females, mean age, and mean empathy values (overall mean of IRI = 54.04, treatment group IRI = 53.60, and control group IRI = 54.55) did not differ statistically significant between the treatment and control group. The videos of the subjects were coded according to whether subjects scratched their face, laughed or yawned while watching the corresponding

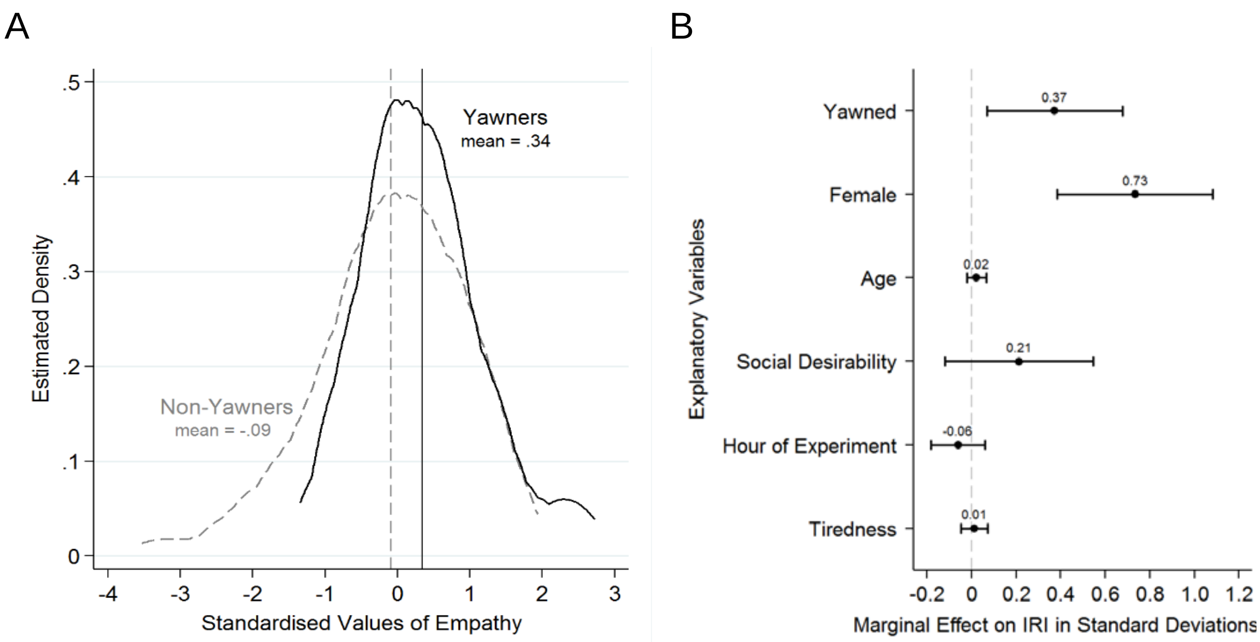
[2] Even through the exposure-time of laughing faces differs in both groups there is no statistical difference of imitation. In the treatment group 60% of participants smiled in response to laughing faces. In the control group 56% smiled. The difference is statistically not significant (t = 0.75). The same results apply to face scratching (22% vs. 29%, t = 1.31).

3 These thirty cases do not differ statistically from the valid observations regarding the assignment to treatments, sex distribution, and IRI values.

videos. In the treatment group 22% (40/183) of subjects yawned. In the control group only 3.3% (5/150) yawned, confirming the notion that practically all yawns in the treatment group occurred because of contagion. Subjects who showed contagious yawning in the treatment group also displayed higher empathy values by 0.43 standard deviations as measured by the IRI. The results are depicted in Figure 5A.

Furthermore, in the treatment group 22.4% of subjects scratched their face in response to the scratching video sequence, and 60.1% laughed during the laughing sequence. In the control group the incidence of scratching and laughing was 28.7% and 56% respectively. However, neither in the control group nor in the treatment group was either scratching or laughing related to empathy values (see Table S7 in the supplement).

Figure 5: The Distribution of Empathy and Predictors of Empathy in Study 2

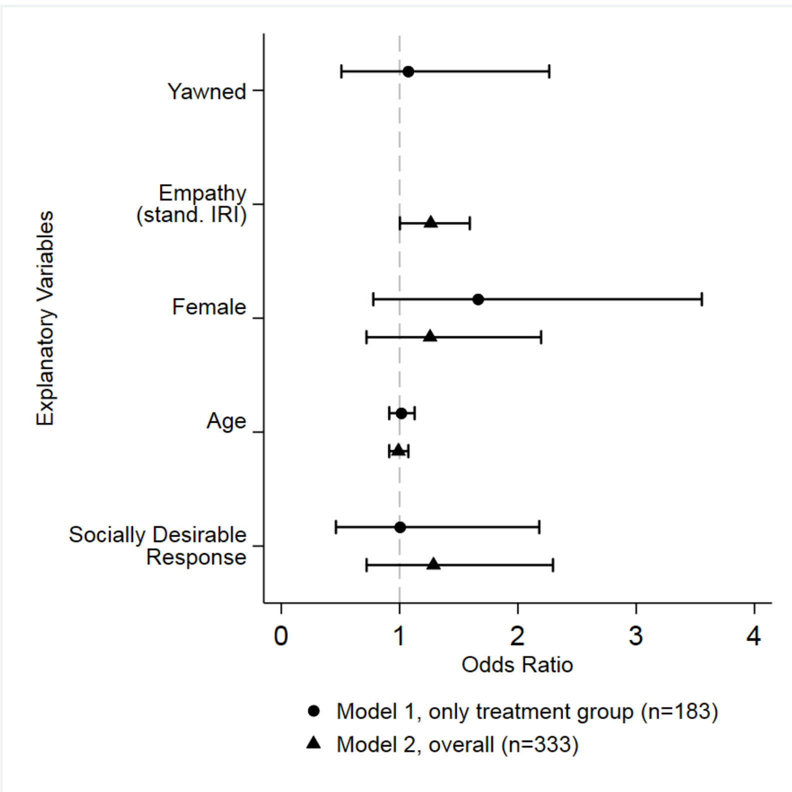


Notes: The plot in panel A shows Kernel density estimates (n = 183) of the z-standardized distribution of empathy as measured by the IRI among individuals in the treatment group not showing contagious yawning (dashed grey curve) (*n* = 143) and individuals who did show contagious yawning (solid black curve) (*n* = 40). Yawners have .43 standard deviations higher empathy values than do non-yawners (-.09 vs. .34). This difference in means is statistically significant ($t(181) = 2.73$, $p = .008$). Panel B represents the coefficient plot of the OLS-Regression of the z-standardized IRI on its predictors (see model 4 of Table S5 in the supplement, *n* = 183, adjusted $R^2 = .12$) in the treatment group including the 95 % confidence intervals.

In study 2 we also measured subjects' susceptibility to social desirability. Subjects who answered "yes" to knowing the fictional tourist site or person were coded as being sensitive to social desirability. The results of the OLS regression are displayed in Figure 5B and show that besides yawning and gender none of the included control variables (age, tiredness, social desirability, and time of the day the experiment took place) is related to empathy. Further analyses on the sub-dimensions of IRI reveal that contagious yawning is statistically significantly related to fantasy taking and empathetic concern, and hence comprises both, an affective and a cognitive aspect of empathy (see Table S6).

Furthermore, we analyzed via logistic regression which subjects decided to donate some (or all) of their experimental payment of 20 Swiss Francs to a charitable organization. The results reveal (see Figure 6) that only empathy predicts the probability of donating. Hence, contagious yawning is an indicator of empathy, which in turn predicts charitable giving. But contagious yawning has no direct effect on charitable giving.

Figure 6: Logistic regression of donation behavior



Notes: Figure 6 displays the coefficient plot of the logistic regression of donation to a charitable organization on its predictors including the 95% confidence intervals (see also Table S8 in the supplement). Further analyses of the sub-dimensions of the IRI show that all are positively related to donating (except for the sub-dimension personal distress) even though not every dimension is statistically significant (see Table S9 in the supplement).

6. Discussion and Conclusion

This study finds clear evidence that the susceptibility to contagious yawning is related to empathy. In study one 24% of the subjects yawned and yawning subjects showed higher empathy values by 0.49 standard deviations when compared to non-yawning subjects. This result was closely replicated in study two in which 22% of the subjects yawned in response to the stimulus video. Our finding confirms previous research, which shows indirect evidence of yawning being related to empathy (Arnott et al. 2009, Norscia et al. 2016, Norscia and Palagi 2011, Palagi et al. 2014, Platek et al. 2003, 2005), and disconfirms the missing evidence reported by Bartholomew and Cirulli (2014). We believe that the association between contagious yawning and empathy was obscured in the study of Bartholomew and Cirulli (2014) for methodological reasons. The authors informed subjects beforehand about the nature of contagious yawning and they relied on the subjects' self-reporting to measure the occurrence of yawning. In contrast, we recorded the subjects on video and thus have a more objective and reliable measure of the occurrence of yawning.

The contagion rate of 24% that we find is comparatively low. One reason for this might be that subjects watched the stimulus videos while other subjects were also present in the laboratory. All workplaces were separated by cubicles in such a way that subjects' faces were not directly observable for other subjects. However, the mere presence of others in the same room might have inhibited contagious yawning as suggested by Gallup et al. (2016).

Furthermore, study two shows that other mimicry, e.g. face scratching or laughing, is not an indicator of empathy. This finding is not in contradiction with the results of Stel et al. (2008) who instructed subjects to imitate others and found elevated empathy levels afterwards. But our results suggest that the simple occurrence of a smile while watching others smile or laugh is not an indicator of empathy as contagious yawning. Taken together, these results suggest that contagious yawning is a very special and distinct phenomenon. It is hard to control and seems to be biologically ingrained in highly social species, such as monkeys, apes and humans. Highly social species often have to rely on the synchronization of behavior, particularly in situations of escaping from predators, coordinating sleep-wake-cycles or adhering to social norms. Hence, it might have been evolutionarily advantageous to be highly susceptible to the emotions and intentions of others, and authors like De Waal (2008) suggest that empathy provides the basis for synchronized motor action and synchronizes emotional states. This, in turn, has positive feedback effects on social cohesion (Palagi et al. 2009, Seyfarth et al. 2013) and promotes helping behavior and identification with conspecifics (Preston and De Waal 2002).

Our study finds only positive evidence for hypotheses A and B, but not for hypothesis C, that contagious yawning has a direct link to pro-social behavior. Yawning subjects did donate more money to an anonymous recipient in the dictator game (study 1). However, the difference between yawners and non-yawners was statistically not significant. The same results holds true with respect to donating to a charitable organization (study 2). Hence, contagious yawning is a signal of empathy but the signal is not very strong or clear. However, using a measure of general empathy and general pro-social behavior (as we did) does not take context into consideration. The relation between contagious yawning and pro-social behavior might indeed be stronger if the pro-social behavior was specific and directed towards members of one's own group.

Moreover, the degree of empathy is also determined by other factors such as gender (as also shown by our results) or presumably through education and socialization (not tested here). Norscia et al. (2016a) and Chan and Tseng (2017) report that females are more susceptible to contagious yawning. Also in our studies, women are more susceptible to contagious yawning (24.4%) than men (19.6%). However, this difference is statistically not significant ($\chi^2 = .97$, $p = .32$, $df = 1$, $N = 354$) confirming the result of various other studies (e.g. Gallup and Massen 2016). However, the IRI shows clearly higher values for women. Hence, we also conclude that women are more empathetic than men, presumably because women are "hard-wired for maternity and parenthood" (Norscia et al. 2016a; for a detailed discussion of the gender effect see also Norscia et al. 2016b).

It is interesting and not easily explained why only contagious yawning is related to empathy in our study, and not scratching or laughing. One interpretation is that scratching and, more so, laughing are more easily controllable behaviors. Individuals might have learned that it is socially expected to imitate a smile or laugh. However, yawning is much harder to control or to suppress and it is therefore harder to be shaped by cultural factors. We believe that the study results represent an important finding and indicate avenues for further research. First, susceptibility to contagious yawning seems to be an implicit test of empathy. Second, the finding that contagious yawing is not generally related to pro-social behavior raises questions whether this association can be found in groups of closer social ties (e.g. as parochial pro-social behavior) along the lines suggested by De Dreu et al. (2010).

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Acknowledgements:

We like to thank Anna Akocsi, Nathalie Eggenberg, Lara Eigenmann, Anissa Heim, Raffaele Keller, Gianna Neeser, Noemi Parlevliet, Sivanujan Selliah, and Laura Zenklusen for assisting the data collection.

Supplementary Materials for

Contagious yawning, empathy and their relation to prosocial behavior

Detailed description of the experimental procedure

For study one 191 student volunteers from the University of Bern from various academic disciplines participated in the experiment. Upon arrival in the experimental laboratory of the University of Bern subjects were seated in cubicles in front of computers (see Figure S1). Computers were connected to a video camera and a pulse-meter which was attached to participants' forefingers. We conducted 22 sessions with 5-10 participants each between 03/24/2015 and 04/29/2015. In 20 cases subjects' faces were not fully visible on the videotapes which left us with 171 cases for the analysis. Sixty-five of the 171 subjects were male (38%), and subjects' average age was 23.7 (min:18 years, max:37 years).

A **B**

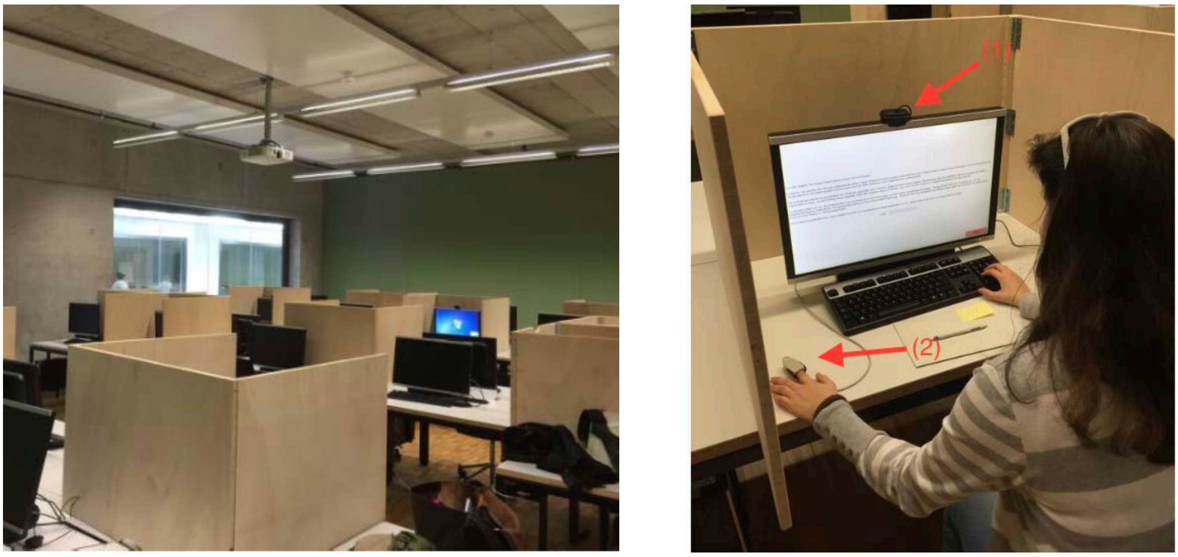

Figure S1: The experimental lab at the University of Bern with 10 cubicles (**A**). The setup of the experiment inside the cubicle (**B**). Upon arrival, the video camera mounted to the computer screen was switched on and closed (1), the pulse-meter (2) was next to the keyboard. After completing the dictator game, the experimental staff opened the camera, switched on the computer screen, and applied the pulse-meter to the participant's index finger.

After being seated, the participants first received the instructions for a dictator game on paper. The experiment was incentivized with 10 CHF. The translated version reads as follows:

Instructions (translated from German)

Dear Participant,

In the following, we will explain to you a decision problem. Please read these instructions carefully and carefully think about your decision by yourself. Please do not hesitate to ask any questions if you need clarification.

You and another person will receive 10 Swiss Francs. You can divide this amount between you and the other person at your discretion.

The other person will be randomly selected among the students of the University of Bern. This person will not be informed about your identity. The person will, however, be informed about the decision problem.

You can split the amount however you like to split it. You could, for example, keep the whole amount, or give everything to the other person. Of course, any amount in between is also possible.

To receive the amount you want to keep without someone else learning about your identity, we posted a sticker with a code to this decision sheet. Please detach the sticker before stuffing the decision sheet into the envelope, and keep the code until the end of the experiment in order to get paid. The staff will later bring a box with sealed envelopes marked with your respective code containing the payments. You will neither be observed by the staff nor by other participants of this experiment when collecting your envelope. Your payment, and thereby your decision, will thus be enclosed to the other participants and the staff.

Please enter your decision into the following boxes

I will keep the following amount:

Please indicate how much you will give to the other participant. Both values have to add up to 10.

If you have made your decision, please put this decision sheet back to the envelope without closing it and put the envelope in the box.

End of Instructions

After filling in the decision sheet, the participants put the sheets into an envelope, which was then collected by a research assistant and handed to a second research assistant outside the lab. The second assistant went to another room to open the envelopes, recorded the decisions along with a unique code number and prepared additional envelopes with the payment. After laying out the envelopes, the second assistant left the room. Meanwhile, the experiment continued at the computer screens placed in front of the participants. The first screen asked the participants for their explicit consent to the experimental procedure, including the measurement of their heart rate and being videotaped. Six participants left after being informed about the procedure or did not turn on the camera.

The second screen showed a three-minute video of yawning faces. During and after the presentation of the videos, participants were videotaped and the heart rate was measured. After the video ended, the participants answered a questionnaire including the German version of the IRI, the Circadian Energy Scale (CIRENS) and some socio-demographic questions at the computer, which completed the experiment. After the experiment which lasted for about 15 to 20 minutes, participants were individually asked to collect their payments in the (now empty) second room by taking away the envelope marked with their code.

Study two was conducted with 363 student volunteers from the University of Bern from various disciplines between 03/22/16 and 04/14/16 in 46 sessions with 5 to 10 participants each. Thirty faces were not fully visible in the videos leaving us with 333 valid cases. Overall, 71.2% (237) of subjects were female and 28.8% (96) male. Subjects’ age ranged from 19 to 34 years with a mean of 23.6. Study two was conducted as study one with a few exceptions. Most importantly, participants were randomized into a treatment group (N=183) and a control group (N=150). The proportion of females, mean age, and mean empathy values (overall mean of IRI = 54.04, treatment group IRI = 53.60, and control group IRI = 54.55) did not differ statistically between treatment and control group. Subjects in the treatment group watched videos of scratching faces for 1.5 minutes, followed by a sequence of laughing faces (1.5 minutes), and yawning faces (3 minutes). In the control group subjects watched only videos of individuals scratching their face for 2 minutes and laughing for 4 minutes. The online questionnaire following the videos was identical in both groups and gathered information on empathy (IRI), tiredness, social desirability, social demographic information (age, sex, subject of study, semester) as well as whether participants wanted to spend some of their experimental payment (20 Swiss Francs) to a charitable organisation.

Additional Statistical Analyses

The IRI index usually contains four sub-dimensions referred to as "perspective taking", "fantasy", "empathetic concern", and "personal distress". The sub-dimension "personal distress" is sometimes excluded from the analysis since it measures self-management rather than empathy. Figure S2 replicates Figure 1 (A) if the sub-dimension "personal distress" is excluded when constructing the additive index separately for yawners and non-yawners. The differences are statistically significant (two-sided t-test, t-value = 2.6134, $p < 0.01$). As compared to the full IRI index reported in the main text, however, the differences are slightly smaller.

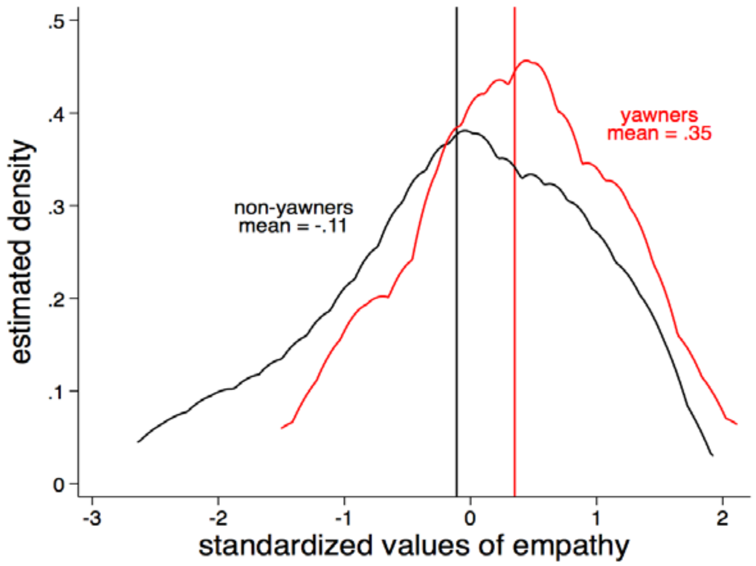

Figure S2: The distribution of empathy if the sub-dimension "personal distress" is excluded when constructing the additive index separately for yawners and non-yawners. The differences between the two distributions are statistically significant.

Table S1 displays the regression analyses reported in Figure 1 (B), now including the constant for the complete IRI as reported in the main text (model 1-3), and for the restricted index excluding the dimension "personal distress" (model 4-6). The results are equivalent. Quantitatively, the full index explains more of the variance, suggesting that contagious yawning has also predictive power for the sub-dimension of "personal distress. "Yawned" is a dummy variable taking the value 1 if the participant has yawned while or after seeing the stimulus video, and the value 0 if he/she has not yawned. Female is a dummy variable taking the value 1 if the participant is female and 0 otherwise. The coefficient for yawning of 0.54 (model 2) indicates that yawning participants have on average a 0.54 standard deviations higher value on the IRI scale. A Wald-test comparing the values of "yawning" to the values of "female" (model 2: $F(1,165) = 0.12$, $P > F = 0.7264$); model 3: $F(1,118) = 0.18$, $P > F = 0.6734$) cannot reject the hypothesis that the two values are drawn from different distributions. This suggests that women (irrespective of yawning) on average have the same degree of empathy as compared to people who yawn (irrespective of gender).

Table S1: OLS Regression of the IRI for study 1

Model	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	stand. IRI full index	stand. IRI full index	stand. IRI full index	stand. IRI rest. index	stand. IRI rest. index	stand. IRI rest. Index
Yawned	0.60***	0.54***	0.49*	0.46**	0.43**	0.42*
	(0.16)	(0.16)	(0.19)	(0.16)	(0.16)	(0.20)
Female		0.63***	0.59**		0.46**	0.41*
		(0.14)	(0.18)		(0.15)	(0.19)
Age		0.02	0.03		0.02	0.03
		(0.02)	(0.03)		(0.02)	(0.03)
CIRENS		-0.07	-0.13		-0.03	-0.10
		(0.08)	(0.10)		(0.09)	(0.11)
Hour of Experiment		0.03	0.06		0.02	0.05
		(0.03)	(0.04)		(0.03)	(0.04)
Average Heart Rate			0.00			0.00
			(0.00)			(0.00)
Constant	-0.14	-1.24	-1.86	-0.11	-1.02	-1.73
	(0.09)	(0.75)	(0.97)	(0.09)	(0.75)	(0.93)
n	171	171	128	171	171	128
adjusted R^2	0.06	0.14	0.13	0.03	0.06	0.06

* p<0.05, ** p<0.01, *** p<0.001, robust standard errors in parentheses.

Table S1: OLS-regressions showing the correlation between empathy as measured by the z-standardized full IRI index (model 1-3) and the z-standardized restricted IRI index excluding the sub-dimension “personal distress” and various explanatory variables. Participants who yawn have higher empathy values than non-yawners. Women are more empathic than men. All other effects are small and statistically insignificant.

Table S2: OLS regression of the sub-dimensions of IRI for study 1

Model	(1)	(2)	(3)	(4)
Dependent Variable (stand. IRI)	Persp. Tak.	Fantasy	Emp. Conc.	Pers. Dist.
Yawned	0.05	0.42*	0.41*	0.41
	(0.23)	(0.18)	(0.19)	(0.21)
Female	-0.04	0.42*	0.48**	0.69***
	(0.19)	(0.19)	(0.18)	(0.17)
Age	0.06*	-0.02	0.03	0.01
	(0.03)	(0.02)	(0.02)	(0.03)
CIRENS	-0.02	-0.15	-0.03	-0.12
	(0.11)	(0.10)	(0.11)	(0.08)
Hour of Experiment	0.03	0.03	0.06	0.04
	(0.04)	(0.03)	(0.03)	(0.03)
Average Heart Rate	0.01	0.00	-0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-2.15*	-0.17	-1.56	-1.23
	(0.86)	(0.85)	(0.93)	(1.03)
n	128	128	128	128
adjusted R^2	0.00	0.08	0.06	0.15

* p<0.05, ** p<0.01, *** p<0.001, robust standard errors in parentheses.

Figure S3 plots the average percentage change of the heart rate for yawning participants. The pattern closely resembles the pattern observed in Corey et al. (2012) except for the shifted peak of the heart rate after yawning. This shift is due to the different coding of the data: while Corey et al. (2012) code the peak of yawning as time = 0, we code the beginning of yawning as time = 0. The peak observed in our data is thus shifted slightly to the right. Also we observe a decline in heart rate before yawning, which is, however, not statistically significant.

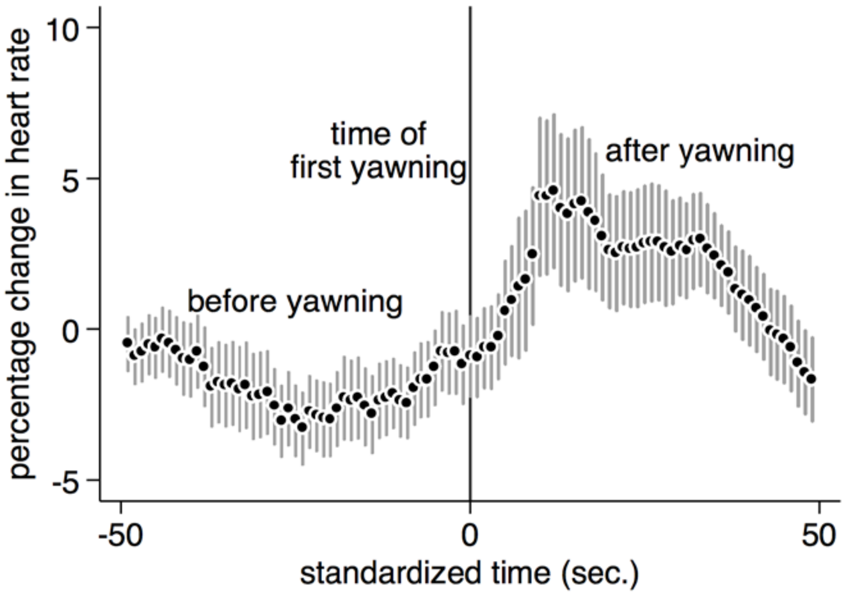

Figure S3: Percentage change in heart rate before, during and after the first yawn of yawning participants. Error bars indicate 95% confidence intervals. The heart rate peaks at the peak of yawning and declines after that.

Table S3: OLS regression of giving in the dictator game in study 1

Model	(1)	(2)
Dependent Variable	Giving (CHF)	
Yawned	0.56	
	(0.44)	
IRI (stand.)		0.43*
		(0.19)
Female	0.19	-0.06
	(0.42)	(0.45)
Age	0.03	0.02
	(0.06)	(0.06)
CIRENS	-0.40	-0.40
	(0.21)	(0.20)
Constant	3.16*	3.67*
	(1.50)	(1.47)
n	171	171
adjusted R^2	0.01	0.03

Notes: * p<0.05, ** p<0.01, *** p<0.001, robust standard errors in parentheses.

Table S4: OLS regression of giving in the dictator game in study 1: Sub-dimensions of IRI

Model	(1)	(2)	(3)	(4)
Dependent Variable		Giving (CHF)		
IRI (stand.)	Persp. Tak.	Fantasy	Emp. Conc.	Pers. Dist.
	0.66***	0.26	0.68***	-0.54*
	(0.19)	(0.21)	(0.18)	(0.22)
Female	0.18	0.11	-0.14	0.60
	(0.41)	(0.43)	(0.44)	(0.43)
Age	-0.01	0.03	0.02	0.03
	(0.06)	(0.06)	(0.06)	(0.06)
CIRENS	-0.45*	-0.40	-0.42*	-0.47*
	(0.20)	(0.21)	(0.20)	(0.21)
Constant	4.31**	3.31*	3.73*	3.23*
	(1.52)	(1.49)	(1.44)	(1.56)
n	171	171	171	171
adjusted R^2	0.07	0.01	0.07	0.04

Notes: * p<0.05, ** p<0.01, *** p<0.001, robust standard errors in parentheses.

Table S5: OLS Regression of the IRI for the Treatment Group of study 2

Model	(1)	(2)	(3)	(4)
Dependent Variable	stand. IRI	stand. IRI	stand. IRI	stand. IRI
Yawned	0.43**	0.39*	0.38*	0.37*
	(0.16)	(0.16)	(0.15)	(0.15)
Female		0.73***	0.74***	0.73***
		(0.18)	(0.18)	(0.18)
Age		0.02	0.02	0.02
		(0.02)	(0.02)	(0.02)
Social Desirability			0.21	0.21
			(0.17)	(0.17)
Hour of Experiment				-0.06
				(0.06)
Tiredness				0.01
				(0.03)
Constant	-0.09	-1.14*	-1.16*	-0.42
	(0.09)	(0.57)	(0.57)	(0.90)
n	183	183	183	183
adjusted R^2	0.0268	0.1180	0.1198	0.1156

Notes: * p<0.05, ** p<0.01, *** p<0.001, robust standard errors in parentheses.

Table S6: OLS regression of the sub-dimensions of IRI for the treatment group of study 2

Model	(1)	(2)	(3)	(4)
Dependent Variable: stand. IRI	Persp. Tak.	Fantasy	Emp. Conc.	Pers. Dist.
Yawned	-0.04	0.46*	0.36*	0.14
	(0.19)	(0.18)	(0.17)	(0.18)
Female	-0.32	0.60***	0.75***	0.85***
	(0.17)	(0.17)	(0.17)	(0.17)
Age	0.03	0.02	-0.00	0.01
	(0.02)	(0.02)	(0.02)	(0.03)
Social Desirability	-0.03	0.20	0.22	0.15
	(0.17)	(0.19)	(0.16)	(0.15)
Hour of Experiment	0.03	-0.11	-0.04	-0.03
	(0.07)	(0.06)	(0.06)	(0.06)
Tiredness	0.00	-0.01	-0.01	0.05
	(0.03)	(0.03)	(0.03)	(0.03)
Constant	-0.79	0.57	-0.14	-0.81
	(1.05)	(0.93)	(0.96)	(1.13)
n	183	183	183	183
adjusted R^2	0.00	0.09	0.11	0.15

Notes: * p<0.05, ** p<0.01, *** p<0.001, robust standard errors in parentheses.

Table S7: OLS Regression of the IRI in study 2 for all subjects

Model	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	stand. IRI	stand. IRI	stand. IRI	stand. IRI	stand. IRI	stand. IRI
Yawned	0.35*				0.34*	0.32*
	(0.16)				(0.16)	(0.15)
Scratched		0.12			0.11	0.20
		(0.12)			(0.12)	(0.12)
Laughed			0.07		0.05	0.07
			(0.11)		(0.11)	(0.10)
Female				0.77***		0.81***
				(0.12)		(0.12)
Age						0.02
						(0.02)
Social Desirability						0.09
						(0.14)
Treatment Group	-0.22	-0.14	-0.15	-0.21*	-0.21	-0.27*
	(0.12)	(0.11)	(0.11)	(0.10)	(0.12)	(0.11)
Constant	0.07	0.05	0.04	-0.44***	0.01	-1.14*
	(0.08)	(0.09)	(0.10)	(0.11)	(0.11)	(0.47)
n	333	333	333	333	333	333
adjusted R^2	0.0128	0.0023	0.0010	0.1227	0.0097	0.1371

Notes: * p<0.05, ** p<0.01, *** p<0.001, robust standard errors in parentheses.

Table S8: Logistic regression of charitable giving in study 2

Model	(1)	(2)
Dependent Variable	Charitable Giving	
Yawned	0.07	
	(0.38)	
IRI (stand.)		0.23*
		(0.12)
Female	0.51	0.23
	(0.39)	(0.28)
Age	0.01	-0.01
	(0.05)	(0.04)
Social Desirability	0.00	0.25
	(0.40)	(0.30)
Constant	-1.41	-0.55
	(1.37)	(1.04)
n	183	333
Pseudo R^2	0.01	0.02

Notes: * p<0.05, ** p<0.01, *** p<0.001, robust standard errors in parentheses.

Table S9: Logistic regression of charitable giving in study 2: Sub-dimensions of IRI

Model	(1)	(2)	(3)	(4)
Dependent Variable		Charitable Giving		
IRI (stand.)	Persp. Tak.	Fantasy	Emp. Conc.	Pers. Dist.
	0.17	0.16	0.28*	-0.05
	(0.12)	(0.11)	(0.12)	(0.12)
Female	0.42	0.32	0.23	0.44
	(0.27)	(0.27)	(0.28)	(0.29)
Age	-0.01	-0.01	-0.01	-0.01
	(0.04)	(0.04)	(0.04)	(0.04)
Social Desirability	0.26	0.26	0.21	0.27
	(0.30)	(0.30)	(0.29)	(0.30)
Constant	-0.67	-0.67	-0.65	-0.81
	(1.00)	(1.02)	(1.01)	(0.98)
n	333	333	333	333
Pseudo R^2	0.01	0.01	0.02	0.01

Notes: * p<0.05, ** p<0.01, *** p<0.001, robust standard errors in parentheses.