UNIVERSITY OF CALIFORNIA

Santa Barbara

# Acetaminophen and Ibuprofen Effects on Ingroup Positivity

A Thesis submitted in partial satisfaction of the

requirements for the degree Master of Arts

in Psychological and Brain Sciences

by

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September 2020

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ABSTRACT

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Every week approximately 57 million adults in the United States take a dose of acetaminophen, and another 42 million take a dose of ibuprofen. These medications – commonly known by the brand-names Tylenol and Advil – are taken with the intent to reduce fever, pain, and inflammation. Recent research has shown that these drugs also have dampening effects on perceptions of social pain, and not just physical pain. In addition, acetaminophen has produced a "blunting" effect on the strength of affective evaluations of stimuli: aversive noise stimuli, and both negative and positive visual stimuli. The current study investigates acetaminophen and ibuprofen's effects on ingroup positivity in a minimal group context, specifically addressing the visual representations of the faces of ingroup versus outgroup members. Our hypothesis is that mental representations of ingroup member faces should be evaluated less positively under the affective blunting influence of acetaminophen. Our study failed to show the predicted blunting effect of acetaminophen on evaluations of representations of ingroup and outgroup members and instead showed the opposite pattern: increased ingroup positivity. Ibuprofen likewise produced representations of ingroup members that garnered greater ratings of ingroup positivity. Our study also included tasks designed to evaluate these medications' effects on two potential

psychological mechanisms underlying the main experimental task: affective evaluations and visual cognition. While the White Noise Evaluation revealed the predicted affective blunting effects of acetaminophen compared to placebo, the Mental Rotation Task for visual cognition skill revealed blunted performance for acetaminophen only as compared to ibuprofen.

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# I. Introduction

If you are in pain, everyone – from a family doctor to a meditation guru – will tell you that there are two ways to reduce it: eliminate the cause or alter the perception. If you are using a chemical substance to alter your perception of pain, it is possible that other perceptions will be altered as well. This is common knowledge when considering alcohol, marijuana, or prescription pain medication; the perceptual side-effects from these substances and the social ramifications of these altered perceptions is well-known and subject to ongoing research. But what about the millions of over-the-counter pain medications that are taken daily in the United States? Are there subtler perceptual changes afoot when we take a tablet to reduce a mild headache? And might those changes likewise affect our social evaluations and behavior?

If you have a headache or a fever, chances are you reach for a product containing acetaminophen or ibuprofen to relieve your perceptions of pain. Acetaminophen[1] is one of the most widely available and frequently used over-the-counter pain medications in the United States. In any given week, an estimated 57 million adults in the U.S., roughly 23% of the adult population, will take at least one dose of acetaminophen. Another 17%, roughly 42 million adults, will take at least one dose of ibuprofen. (Kaufman, et al. 2002). But there is evidence that both drugs do not stop at merely reducing physical pain, but also affect a number of psychological processes.

[1] The active ingredient in Tylenol. Acetaminophen is referred to as "paracetamol" in all areas of the world outside of the United States, Canada, Japan, Venezuela, Colombia, and Iran. Both names are fragments of the full chemical name for the compound: para-acetylaminophenol. The medical abbreviation for the drug – APAP – is also derived from the chemical name, rendered as **a**cetyl-**p**ara-**a**mino**p**henol.

### *A. Acetaminophen and Ibuprofen Effects on Social Perceptions*

Acetaminophen has been shown to not only reduce physical pain, but to blunt feelings of social pain due to social rejection and exclusion (DeWall et al., 2010) as well as to reduce empathy for the pain of others (Mischkowski et al., 2016). Ibuprofen has also been shown to reduce feelings of social pain from social rejection, as well as to blunt the intensity of reported pain from a remembered experience of both physical and social pain in women (Vangelista et al., 2014). This social pain-blunting pattern did not hold for men in the one study by Vangelista and colleagues that has investigated ibuprofen's effects on social pain, suggesting a potentially more complex interaction of medication, body chemistry, and psychological mechanisms in the case of ibuprofen than our study seeks to address at this time. However, the fact that ibuprofen has been shown under certain circumstances to blunt social pain in a similar way to acetaminophen, together with their overlapping abilities to address physical pain and fever, makes ibuprofen an interesting and important medication to include in work addressing pain-killer influence on psychological processes.

### *B. Acetaminophen Effects on Affective Evaluation of Visual Stimuli*

Acetaminophen's more generalized blunting effect on socially induced psychological pain has led researchers to investigate whether acetaminophen has a blunting effect on other types of evaluations. At Ohio State University, Durso and colleagues (Durso et al., 2015) had participants take a dose of acetaminophen and then evaluate images from the IAPS image set, a stimuli set that elicits stable ratings of both negative-valenced and positive-valenced affect (Lang et al., 2008). Researchers found that acetaminophen blunted the strength of the affective evaluations that participants made on both ends of the valence spectrum: negative

images were evaluated less negatively, and positive images were evaluated less positively. The fact that acetaminophen ameliorates the evaluations of both negative physical and social experiences made it a reasonable prediction that it would likewise decrease the negativity of evaluations of negative images. But the results of acetaminophen on evaluations of positive images potentially implies a more generalized blunting of certain psychological processes related to evaluation and, perhaps even perception.

Building on the result that acetaminophen blunted the evaluation of positive images, the current study sought to investigate how acetaminophen might affect the evaluation of other, positive visual images: facial representations of ingroup members.

### *C. Reverse-Correlation Image Classification and Minimal Group Paradigm*

In the past several years, reverse-correlation image classification has emerged as a sensitive way to measure intergroup bias (Dotsch et al., 2008). This is a data-driven method of obtaining visual representations of the mental representations of group members. This is accomplished by having participants do a forced-choice task between two faces, over hundreds of trials. The faces are comprised of the same "base" face image, upon which a layer of visual "noise" is applied.

This noise layer obscures sharp detail and makes some facial features more ambiguous. This method of image categorization is used to measure intergroup bias by asking participants to "select the face that looks more _____," and filling in the blank with a group-of-interest. The noise layers of all the participant choices are then averaged together and layered back onto the base face to create a composite representation of a member of the group in question. Using these composite faces as stimuli in an evaluation task can then yield

information about the underlying intergroup bias that was in play when the faces were being generated during the forced choice task.

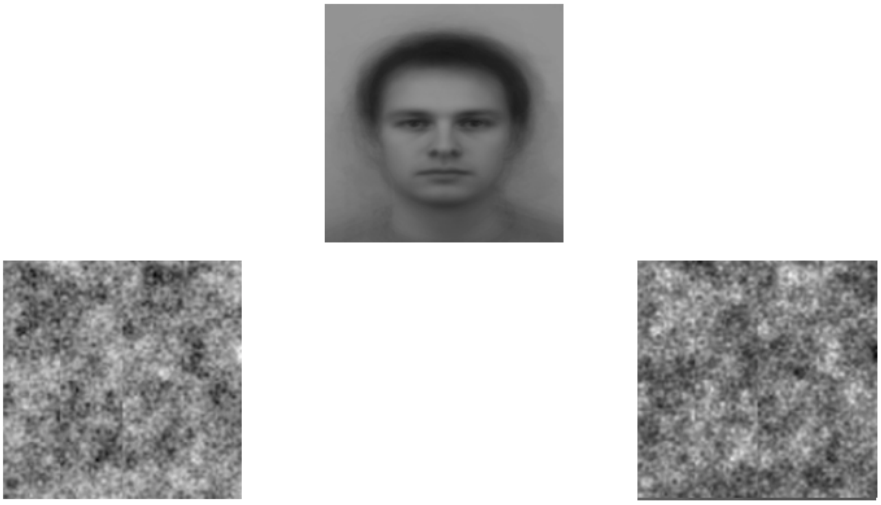

Figure 1: The Caucasian male base face image, and two versions with a layer of visual noise. The noise layer in this figure is the same pattern, and the same transparency; the only difference is that the noise layer on the right is an inversion of the black/white colors of the noise layer on the left. In the context of a forced-choice categorization task, participants would be asked to choose either the left or right face, based on whatever instructions they were given to use as criterion.

Since the result of this task is to have a set of visual images of faces evaluated for traits which can be related to feeling positive or negative about the face, based on the results from Durso and colleagues, we might hypothesize that a medication such as acetaminophen might exert an influence on the process. But rather than having the participants who rate the images take acetaminophen, we are interested in the evaluations that participants are making during the forced choice face categorization task. When they are being asked to choose between two faces, they are presumably doing so utilizing some sort of evaluative process. If it is an evaluative process that is affected by acetaminophen, or ibuprofen, then the evidence

of that influence would be in the composite faces that are generated after taking those medications.

The evaluation that is being made when choosing between the two faces is one related to group membership, because the two faces are said to each represent a different group: one the participant belongs to and one that they do not. The groups may be relevant and extant groups – such as ethnic groups – or they may be arbitrary groups, where membership is assigned via a Minimal Group Paradigm. A well-established method of studying intergroup bias in a laboratory setting is to make use of the Minimal Group Paradigm (Tajfel, 1970), and this methodology sorts participants into arbitrary groups. For example, the version that our study utilizes has participants estimate the number of dots that flicker on a computer screen, and then classifies them as either "over-estimators" or "under-estimators." However, this group assignment is just that: an assignment. It is not an assessment of any ability or preference on the part of the participant. Nevertheless, this methodology has revealed that even arbitrary distinctions between groups can influence the participants to favor their ingroup over the outgroup; the mere categorization into groups is sufficient to produce discriminatory intergroup behaviors in the form of ingroup favoritism.

This ingroup favoritism or positivity, rather than outgroup derogation, is a consistent and important feature of intergroup bias (Brewer, 1999). This makes sense especially in the Minimal Group Paradigm: since the group divisions are arbitrary there is no reason for participants to harbor negative feelings toward the outgroup. It is merely their inclination to feel positively toward their own ingroup that nudges their behavior to favor the ingroup. Social Identity Theory (Tajfel & Turner, 1979) predicts this, and was crafted as a theory to

explain the results of the original Minimal Group Paradigm studies. Social Identity Theory proposes that group membership grants individuals a social identity, and once a person adopts this social identity it not only becomes an important source of self-esteem and belongingness, but it also triggers social comparison. Social comparison, and a desire to see one's self in a positive light, combine to cause positive ingroup evaluations.

In the context of the reverse-correlation image classification task – where the base face is identical and the obscuring noise layer is limited in its power to significantly alter features on any given trial – these positive ingroup evaluations should therefore be more likely to drive participants to select the faces that they evaluate as being more pleasant as being those that are representative of their ingroup. But if their ability to evaluate visual images as being "pleasant" has been affected by the medication they have taken, then the faces they choose may be more neutral than positive.

Ingroup favoritism may be driven by many psychological mechanisms, including both affect and cognition. If the medications that participants take do alter the evaluations they make of the faces of ingroup and outgroup members, then it serves us to attempt to disentangle which foundational psychological processes may be the ones affected by the medication.

### *D. Affective Evaluations*

In order to evaluate medication effects on affective evaluations that do not involve visual imagery or social evaluations, we utilized a White Noise Evaluation task. This involves having participants listen to 3-second "bursts" of white noise, and then evaluating them for pleasantness. This is similar to the affective evaluation of visual images that Durso

and colleagues found, and evaluations of the pleasantness of these sounds has been shown to be blunted by acetaminophen in the same way that acetaminophen blunted evaluations of visual images (Mischkowski et al., 2016). The White Noise Evaluation task also asks participants to rate the noises for their loudness, which is perhaps a less affectively driven and more cognitively driven type of evaluation. Therefore, there may be some ability to parse differential effects on affective and cognitive processes even just within White Noise Evaluation results.

### *E. Visual Cognition*

Since generating a mental representation of a group member's face presumably involves some sort of visual cognition, testing for medication effects on a visual cognition task that does not involve faces is also informative. The Mental Rotation Task is a canonical test of visual cognitive ability (Vandenberg & Kuse, 1978): the images of shapes are presented to participants, who must match it to an image that represents the original image after it has been rotated. If the medications influence the performance of this kind of task, it may speak to their effects on basic visualization procedures and the formation of mental representations of visual imagery.

### *F. Study Overview and Hypotheses*

The first question our study addresses is whether acetaminophen and ibuprofen influence the mental representations of ingroup and outgroup faces. Facial representations were chosen because faces are important in social interactions because of the diversity of information they can convey, and even written information describing physical features can lead to stereotype activation (Anderson & Klatzky, 1987). The current study is based on the

work by the principal investigator while at Ohio State University (Ratner, unpublished), which found that acetaminophen blunted ingroup positivity as measured by trait evaluations of facial representations of ingroup and outgroup members.

We predicted that the current study would find that when facial representations of ingroup and outgroup members were generated by participants on a non-medicinal placebo, the ingroup member face would be rated more positively than the outgroup member face. But for those faces generated by participants in the acetaminophen condition, there would be little or no difference in the trait ratings given to the ingroup versus the outgroup due to acetaminophen blunting the participants' ingroup positivity.

Given that ibuprofen and acetaminophen are both pain reducers, but do not have the exact same neurochemical effects, it was unclear whether ibuprofen would have the same effect on ingroup and outgroup mental representations as acetaminophen. However, the results of this more exploratory condition could shed light on how to proceed with future studies that include ibuprofen.

Another question we address with our study is whether ingroup positivity is driven by affect toward group members, cognitive representations of group members, or both. This will be investigated with separate tasks that have participants engage in those psychological mechanisms in a context devoid of facial imagery, group distinctions, or other social context. We can therefore use this neurochemical approach as way to tease apart this distinction between the potential affective and cognitive mechanisms driving ingroup positivity.

## II. Methods

This study consisted of two phases. In Phase 1, participants were randomly assigned to ingest one of three drugs: placebo (n= 101), acetaminophen (n=102), or ibuprofen (n=104). After being assigned a group membership, they were asked to evaluate and categorize faces as being either of an ingroup member or an outgroup member. Their choices in this face categorization task were used to generate stimulus materials – visual representations of the average ingroup and outgroup member face – for six conditions: Placebo-Ingroup (n=51), Placebo-Outgroup (n=50), Acetaminophen-Ingroup (n=50), Acetaminophen-Outgroup (n=52), Ibuprofen-Ingroup (n=50), and Ibuprofen-Outgroup (n=54). These six condition-level faces were then evaluated on 13 personality traits by participants in Phase 2.

In addition to these trait evaluations in Phase 2, participants in Phase 1 completed a White Noise Burt Evaluation task to assess the drugs' effects on affective evaluations of noise pleasantness. Phase 1 participants also completed a Mental Rotation Task to assess the drugs' effects on visual cognition. These tasks were chosen to probe two of the psychological mechanisms underpinning the categorization of a visual image as representing an ingroup or outgroup member: affective evaluation and visual cognition.

### *A. Participants*

307 UCSB students were recruited to participate in exchange for course credit. The average age of the subjects was 19 years old, with a range from 17 to 26 years old. Approximately 60% of the participants were female (179) and 40% male (119); nine subjects did not give their gender identification. Caucasian subjects made up 31.2% of the sample,

followed by Asian subjects with 25.8%, Hispanic subjects with 25.5%, multiracial subjects with 9.8%, self-identified "other" with 4%, Black/African-American with 2.7%, and Native Hawaiian/Pacific Islander with 0.7%; nine subjects did not give their ethnic identification.

The recruitment materials included a truncated list of contraindicated medications and medical conditions; 24-hours before the session the full list of contraindications from the consent form was emailed to the participants, as well as instructions to refrain from eating for three hours prior to the study to minimize the variability in drug-absorption rates across participants.

### *B. Procedure: Phase 1*

This was a double-blind, placebo-controlled study. Prior to the participant's arrival, the medications were dispensed. Medications were each measured in a separate graduated cylinder that was dedicated to each medication, in order to avoid any potential cross-contamination of the medications. In order to maintain the blind, the bottles of medication were anonymized with plain paper labels, each bearing a non-identifying code letter, the volume of medication to be dispensed as a single dose, and instructions to shake the bottle well before dispensing. The medications were dispensed from the graduated cylinders into plastic medicine cups labelled with the participant ID number and the code letter corresponding to the medication bottle from which the medicine was dispensed.

Oral suspensions of the medications were used, rather than capsules or tablets, to minimize absorption time once ingested. Extra-strength adult dosages of the medications

were used both to both maximize the safe dosage for our participants and to represent an ecologically valid dose that is often taken in non-laboratory settings.

Oral suspension acetaminophen was in a concentration of 160mg/5mL. An adult, extra-strength dose of acetaminophen is 1000mg, so 31.25 mLs of medication was dispensed per dose. Oral suspension ibuprofen was in a concentration of 100mg/5mL. An adult, extra-strength dose of ibuprofen is 400mg, so 20mLs of medication was dispensed per dose. We selected a volume of 24.5mLs for our oral suspension placebo, Ora-Blend, to place its volume between the two volumes of medication. Ora-Blend is a flavored suspending vehicle that is used by physicians and pharmacists in drug compounding and has a flavor and consistency similar to oral suspension medications.

1. Arrival and Consent

Upon arrival, participants were asked to complete the full consent form and were told that they would be participating in a double-blind study with an equal chance of ingesting acetaminophen, ibuprofen, or a placebo. Participants were informed that the purpose of the study was to evaluate how acetaminophen and ibuprofen effect "how information is processed in the brain." Participants completed the study within one of four semi-private cubicles in a room dedicated to behavioral studies. Anywhere from one to four participants were run simultaneously per session.

2. Body Temperature #1

After the participants completed informed consent procedures their body temperature was recorded using an Exergen temporal artery thermometer on the forehead. Room

temperature in the testing room was also recorded for each session. Body temperature measures were included because both acetaminophen and ibuprofen are anti-pyretic medications, meaning that they reduce fever, and we were interested in whether body temperature would be reduced on these medications.

3. Medication Ingestion

Participants then ingested their dose of either placebo, acetaminophen, or ibuprofen and the time at which they ingested the medication was recorded.

4. Pre-Task Questionnaires

After taking their dose, participants waited to begin the main task of the study for 45 minutes, to allow for the medications to absorb into their systems (Mischkowski et al., 2016; Durso et al., 2015). In the 45-minute interim before the main task, participants completed several questionnaires on a computer, evaluating for social dominance, personal and collective self-esteem, need to belong, and belief in a dangerous world. Our focus for this study is on drug condition effects, and not individual differences, but we are collecting this individual difference information to allow us to explore potential individual difference x drug effects on intergroup bias. This is motivated by previous studies (Gramzow & Gaertner, 2005; Rocass & Brewer, 2002; Tajfel & Turner, 1986) which suggest that individual differences can contribute to ingroup bias.

5. White Noise Burst Evaluation

In October 2016, six months after data collection began, this task was added to the study. 108 subjects participated; 36 of these participants took ibuprofen, 34 placebo, and 38

acetaminophen. Recently published research had found that a 1000mg dose of acetaminophen reduced negative responses to noise blasts (Mischkowski et al., 2016), and so this task was added to our study for two purposes: if we replicated the Mischkowski and colleagues results it could be interpreted as an indirect measure that the drugs had reached efficacy in our participants. The other purpose for adding this task was to determine if acetaminophen was having the predicted blunting effect on affective evaluations in our study, and also to separately evaluate participant evaluations of the noise bursts' "pleasantness," from their evaluations of the noise bursts' "loudness," a more cognitive evaluation.

Participants listened to five white noise "bursts," each 3-seconds long. The calibrated volumes of these bursts were 75, 80, 85, 90 and 95dB, and they were presented in the same randomized order for each participant. Participants rated each white noise burst for both pleasantness and loudness immediately after hearing it, using a visual analog scale on the computer and moving a pointer on a line between two labeled anchor points at 0 and 1. For pleasantness: the 0-anchor point was labeled "Unpleasant" and 1-anchor point was labeled "Pleasant." For loudness, the 0-anchor point was labeled "Quiet" and the 1-anchor point was labeled "Loud."

6. Numerical Estimation Style (NEST)

Next, a classic "dot estimation" minimal group procedure was used to assign participants to arbitrary groups. Participants were asked to estimate the number of dots in 10 rapidly presented patterns on a computer screen, and at the end of the test, the computer program provided feedback indicating that the participant was either an "over-estimator" or an "under-estimator." This feedback was pre-determined and counterbalanced across

participants. The dot estimation task does not actually assess any perceptual tendency, it is only the basis for plausible group assignment in accordance with the Minimal Group Paradigm.

7. Face Categorization

Participants then completed a forced-choice face categorization task on the computer for 450 trials, replicating or increasing the number of trials used in prior studies utilizing this paradigm (Ratner et al., 2014; Dotsch et al., 2008; Mangini & Biederman, 2004). On each trial, participants viewed two adjacent face images; these faces were derived from the same base face image: a grayscale, male face. Noise patterns were layered over the face image to make each face look different by distorting the various facial features and overall facial structure. To make the face categorization task seem plausible, participants were told that past research had shown that people are able to reliably detect the numerical estimation style of others from their faces, and that the purpose of the study was to test whether people can determine numerical estimation style even when face images appear blurry.

Participants were told that on each trial one of the faces was of an over-estimator and the other was of an under-estimator. Participants were always asked to choose which face represented an over-estimator. Thus, those participants who were assigned as over-estimators were looking for faces that represented ingroup members, and participants who were assigned as under-estimators were looking for faces that represented outgroup members. To keep their own group membership salient throughout the main task, an experimenter wrote

each individual participant's group membership onto a sticky note and placed it in their line of sight at the bottom of their computer monitor.

8. Mental Rotation Task

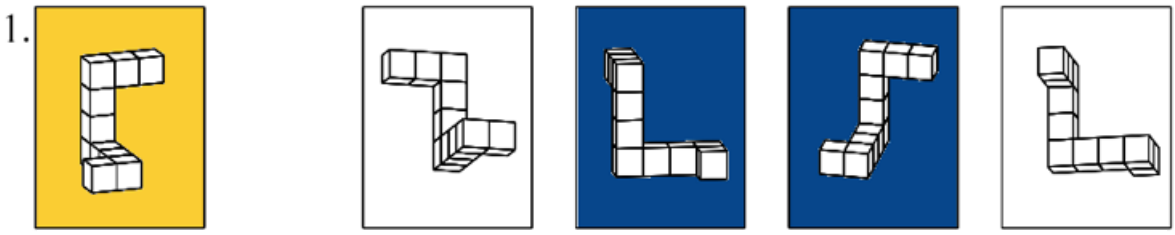


Figure 2: Example of a Mental Rotation Task item. Color coding for illustrative purposes only; figures were black-and-white in the study materials.

In order to evaluate acetaminophen and ibuprofen's effects on visual cognition skills, following the Face Categorization task was a spatial reasoning task called the Mental Rotation Task (Peters, et al. 1995; Vandenberg & Kuse, 1978). This task tested whether acetaminophen or ibuprofen influence cognitive visualization tasks in the absence of social context or content, which might be present in face images. Participants had unlimited time to complete this task, using pencil and paper materials. On each of ten trials participants viewed a drawing of a 3D image made up of ten cubes arranged such that no more than two sides touch. Participants then choose from four options the two which are accurate representations of the item under rotation.

9. Post-Task Questionnaires and Debriefing

After the main task, participants completed more questionnaires on the computer, evaluating three-domain disgust, vividness of visual imagery, and perceived vulnerability to

disease, as well as reporting on any changes to their own health symptoms over the course of the study. These surveys were included to evaluate potential effects from the medications on perceptions of disease vulnerability and potential pathogens, their influence on visual imagination, and to ensure that participants could report any symptoms induced or alleviated from taking the medications. Participants were then fully debriefed as to the purpose of the study and the purposes of the tasks they completed.

10. Body Temperature #2

After the funnel debriefing, participants' body temperature was recorded a second time using the same Exergen temporal artery thermometer on the forehead. This was the final task of Phase 1 of the study.

### *C. Interim between Phase 1 and Phase 2: Stimuli Generation*

To generate the faces to be evaluated by the MTurk participants in Phase 2, we used a technique called reverse correlation image classification (Dotsch et al., 2008; Ratner et al., 2014). Reverse correlation image classification is a method to create visual renderings of people's mental representations of faces by creating an average over hundreds of trials. First, participant-level mean parameters are created by averaging together the noise patterns from all 450 of each participant's choices in the force choice face categorization task. Next, condition-level classification images were created by averaging together the participant-level mean parameters for each condition and superimposing these normalized averages on the original base image. These six condition-level images therefore represent the average ingroup

and outgroup member faces chosen by participants who took placebo, acetaminophen, and ibuprofen.

### *D. Procedure: Phase 2*

To evaluate the faces that were chosen by the participants in the Face Categorization Task of Phase 1, we then recruited 101 participants from Amazon Mechanical Turk (MTurk) who were naïve to the procedures performed in Phase 1. This sample was 58.4% male and 41.6% female; 82.2% of the subjects were Caucasian, 6.9% were Black/African-American, 5% were Asian, 3% were Hispanic, and 3% were Black-White biracial. The mean age was 36.7 years old, with participants representing a range from 22-65 years old. All MTurk participants were based in the United States, were English-speakers, and were paid $1.00 for their participation. MTurk participants were utilized primarily because the ability to obtain quick participation from dozens of participants for a brief task is much more efficiently managed by using online participants.

MTurk participants were presented with the six condition-level classification images, labeled only with a letter A-F, and presented in a randomized order. These participants rated each image on 13 trait dimensions: *trustworthy, attractive, dominant, caring, sociable, confident, emotionally stable, responsible, intelligent, aggressive, mean, weird, and unhappy* (Oosterhof & Todorov, 2008). Ratings were made on a 7-point Likert scale, and each face was rated on all 13 traits before participants moved on to rate the next face in the task.

## III. Results

These are the faces that were generated from the choices made by the participants in the forced choice face categorization task in Phase 1 of the study. So, the "Placebo Ingroup Member" face represents the aggregate choices of all 51 participants who took placebo and were assigned as an over-estimator in the NEST task.

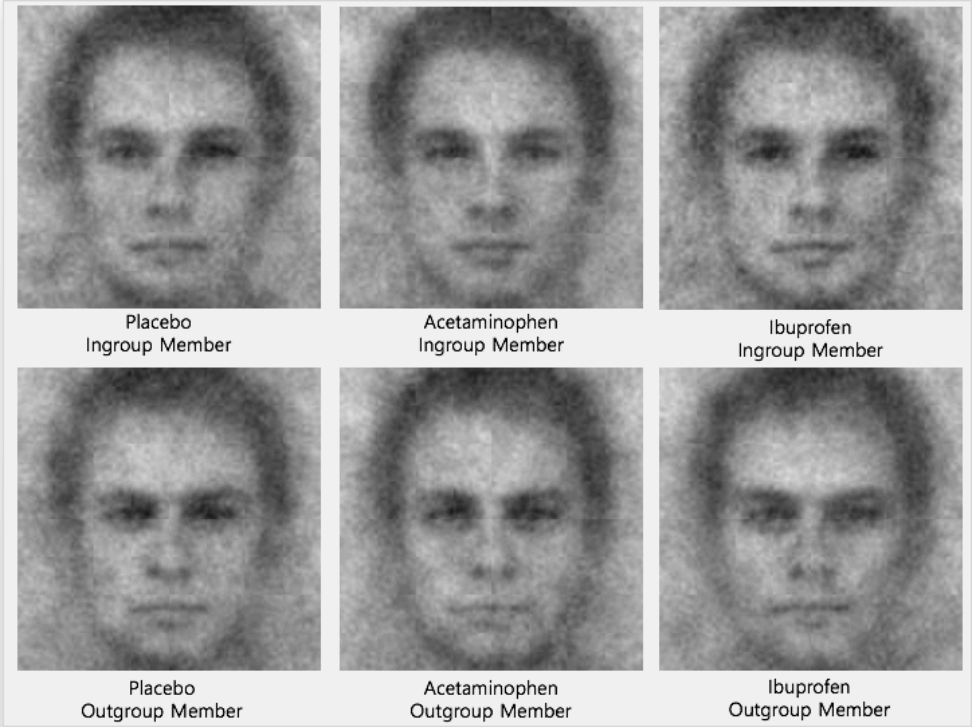


Figure 3: Condition-level face images from Phase 1 of the study.

### *A. Face Categorization*

The MTurk participants provided ratings on the 13 trait dimensions, from which we can infer ingroup/outgroup differences such as ingroup positivity. The traits *aggressive, mean, weird,* and *unhappy* ratings were reverse-scored so that across the board higher ratings would reflect greater positivity about the face in question.

Our predictions were that the faces that reflected the choices of the participants who had taken placebo would show that the ingroup face was rated more positively than the outgroup member face, but that the faces that reflected the choices of participants who took acetaminophen would show no difference in positivity ratings for the ingroup and outgroup member face. This is due to acetaminophen's documented effects on blunting the evaluations of both negative and positive images; if the participants on acetaminophen had blunted evaluations of these images in the predicted way, then there should be little difference in the independent positivity ratings on the ingroup and outgroup member faces.

A 3x2 repeated-measures ANOVA was conducted on the trait ratings, investigating main effects of both drug (placebo/acetaminophen/ibuprofen) and group (ingroup/outgroup) as well as the interaction of drug and group. A repeated-measures ANOVA was used because all the MTurk participants rated all six of the faces. Follow-up paired t-tests were conducted on each drug-group pair to investigate significant differences. In all but eight of the 78 statistical results generated from these tests there were significant differences. The main effect of drug was significant for every trait, as was the interaction of drug and group. The main effect of group only failed to reach significance for Attractiveness, Emotional Stability, Intelligence, Sociability, Weirdness (reverse scored), and Unhappiness (reverse scored). For the paired t-tests, the only pairs which failed to reach significance were the Placebo-Ingroup versus Placebo-Outgroup for Confidence and Weirdness (reverse scored). See Figure 7 and Appendix A for full results of these statistical tests.

Contrary to our hypotheses, when examining the mean trait ratings, we did not see a blunting of ingroup positivity in the acetaminophen group. In fact, both acetaminophen and

ibuprofen conditions showed stronger ingroup positivity than the placebo condition (Figures 4-6).

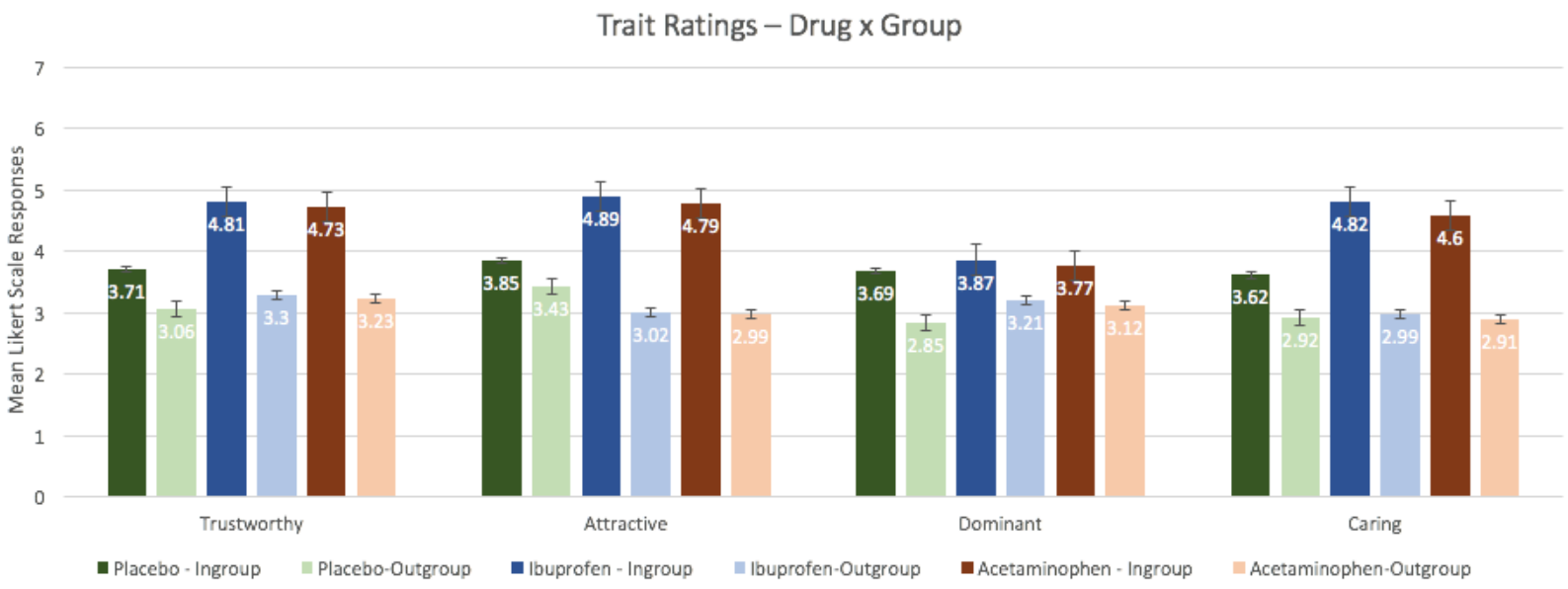


Figure 4: Mean trait ratings on a 7-point scale for trustworthiness, attractiveness, dominance, and caring, by drug and group. Standard errors for all 13 traits ranged between .133 and .179.

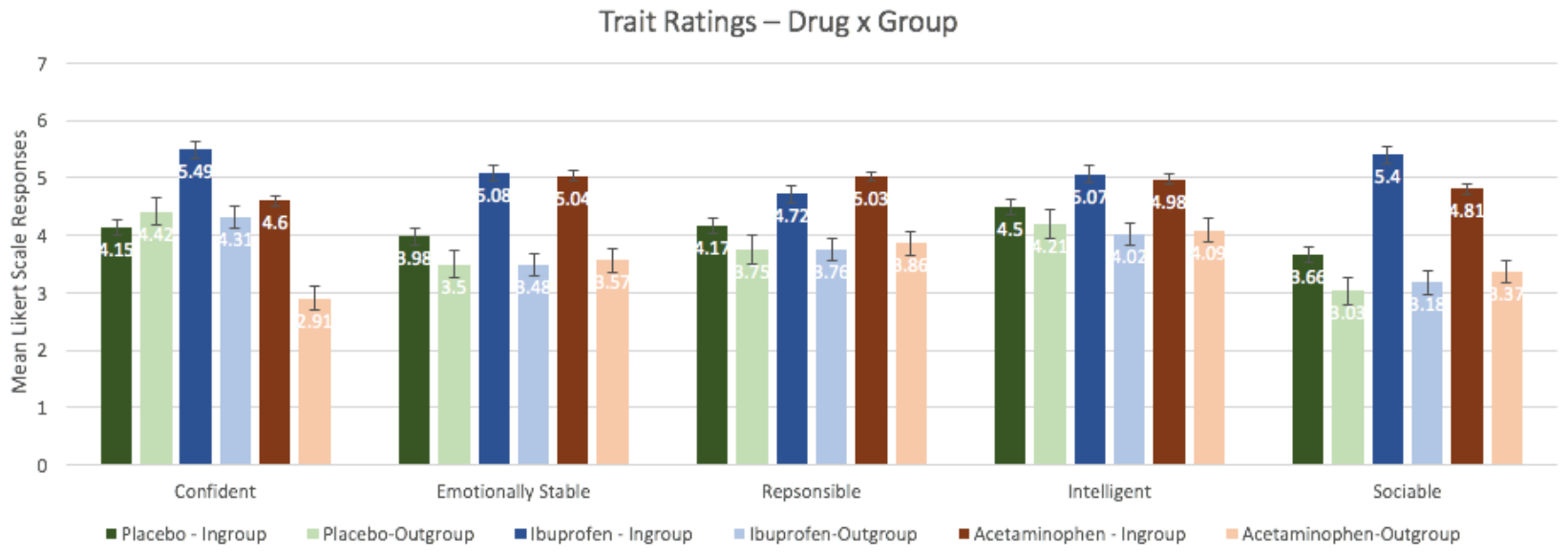


Figure 5: Mean trait ratings on a 7-point scale for confidence, emotional stability, responsibility, intelligence, and sociability, by drug and group.

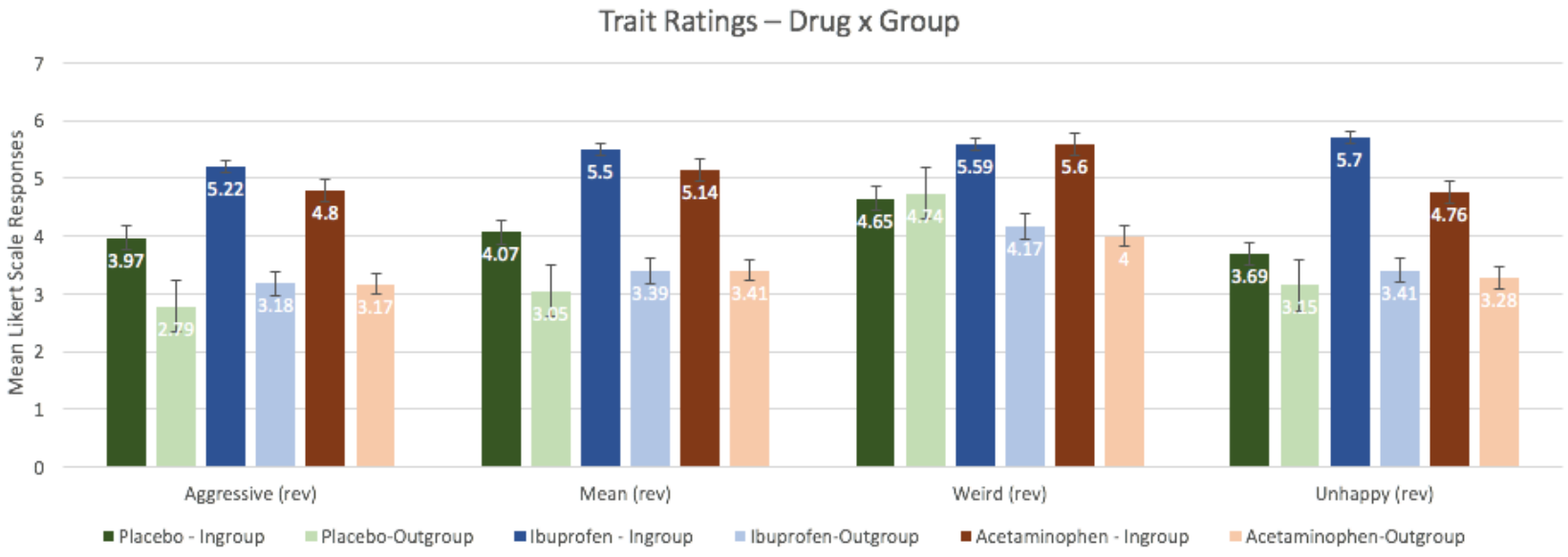


Figure 6: Mean trait ratings on a 7-point scale for aggressive, mean, weird, and unhappy by drug and group. These traits are reverse scored, so higher ratings indicate less aggressive, less mean, etc.

| | ANOVA | | | | | | Paired t-tests | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Main Effect: Drug | | Main Effect: Group | | Interaction: Drug x Group | | Placebo: Ingroup x Outgroup | | Acetaminophen: Ingroup x Outgroup | | Ibuprofen: Ingroup x Outgroup | |
| Trait | F(2,200) | p | F(1,100) | p | F(2,200) | p | t(100) | p | t(100) | p | t(100) | p |
| Trustworthy | 34.1 | p<.001 | 4.86 | p=.03 | 72.37 | p<.001 | 4.13 | p<.001 | 8.96 | p<.001 | 7.44 | p<.001 |
| Attractive | 79.08 | p<.001 | 2.36 | p=0.13 | 73.38 | p<.001 | 3.01 | p=.003 | 11.36 | p<.001 | 10.49 | p<.001 |
| Dominant | 12.57 | p<.001 | 9.92 | p=.002 | 11.53 | p<.001 | -5.47 | p<.001 | -3.13 | p=.001 | -3.4 | p=.001 |
| Caring | 62.71 | p<.001 | 4.81 | p=.03 | 63.95 | p<.001 | 4.51 | p<.001 | 10.11 | p<.001 | 7.44 | p<.001 |
| Confident | 11.1 | p<.001 | 6.87 | p=.01 | 33.18 | p<.001 | -1.64 | p=.10 | 3.88 | p<.001 | 6.34 | p<.001 |
| Emotionally Stable | 42.34 | p<.001 | 1.33 | p=.25 | 55.7 | p<.001 | 3.23 | p=.002 | 7.69 | p<.001 | 8.64 | p<.001 |
| Responsible | 22.06 | p<.001 | 6.47 | p=.013 | 31.91 | p<.001 | 2.78 | p=.007 | 8.34 | p<.001 | 5.36 | p<.001 |
| Intelligent | 31.05 | p<.001 | 0.32 | p=.57 | 20.93 | p<.001 | 2.26 | p=.026 | 5.93 | p<.001 | 7.34 | p<.001 |
| Sociable | 57.07 | p<.001 | 0.35 | p=.55 | 110.56 | p<.001 | 4.26 | p<.001 | 8.96 | p<.001 | 12.4 | p<.001 |
| Aggressive (r.s.) | 63.15 | p<.001 | 5.92 | p<.001 | 79.52 | p<.001 | -6.74 | p<.001 | -7.98 | p<.001 | -11.25 | p<.001 |
| Mean (r.s) | 49.18 | p<.001 | 5.36 | p=.023 | 78.39 | p<.001 | -5.75 | p<.001 | -9.03 | p<.001 | -9.86 | p<.001 |
| Weird (r.s.) | 46.14 | p<.001 | 0.12 | p=.73 | 24.75 | p<.001 | 0.64 | p=.52 | -8.71 | p<.001 | -6.71 | p<.001 |
| Unhappy (r.s.) | 57.9 | p<.001 | 0.83 | p=.37 | 81.65 | p<.001 | -3.13 | p=.002 | -7.73 | p<.001 | -12.22 | p<.001 |

Figure 7: Full results of the ANOVA and paired t-tests for the 13 trait ratings on the faces representing drug x group conditions. Full text results, including means and standard deviations, are located in Appendix A.

### *B. Body Temperature*

The measures of participant body temperature that were taken in Phase 1 before drug ingestion and at the conclusion of the study session were analyzed. Pre-ingestion temperatures ranged from 98.7-100.1 degrees Fahrenheit. Post-session temperatures ranged from 96.4-99.7 degrees Fahrenheit. The difference between these two temperature readings was calculated and expressed a range from -2.5 degrees Fahrenheit to +1.7 degrees Fahrenheit of temperature change from the start of the study to the conclusion. The temperature difference values were then analyzed as a one-way ANOVA by drug type. There were no significant differences based on the medication that was taken on the change in participant body temperature.

### *C. White Noise Burst Evaluations*

This task had participants rating the pleasantness and loudness of five different decibel levels of white noise. We predicted that the medications would have the same blunting effect on pleasantness evaluations as was present in the Mischkowski and colleagues' study. This would both show that the medications were affecting a more affective evaluation – how pleasant a stimuli is – and also, due to the replication nature of this task ,it would provide evidence to infer that the medications in our study had been absorbed prior to the main task.

A repeated-measure ANOVA was run on loudness ratings and on pleasantness ratings across the five decibel levels.

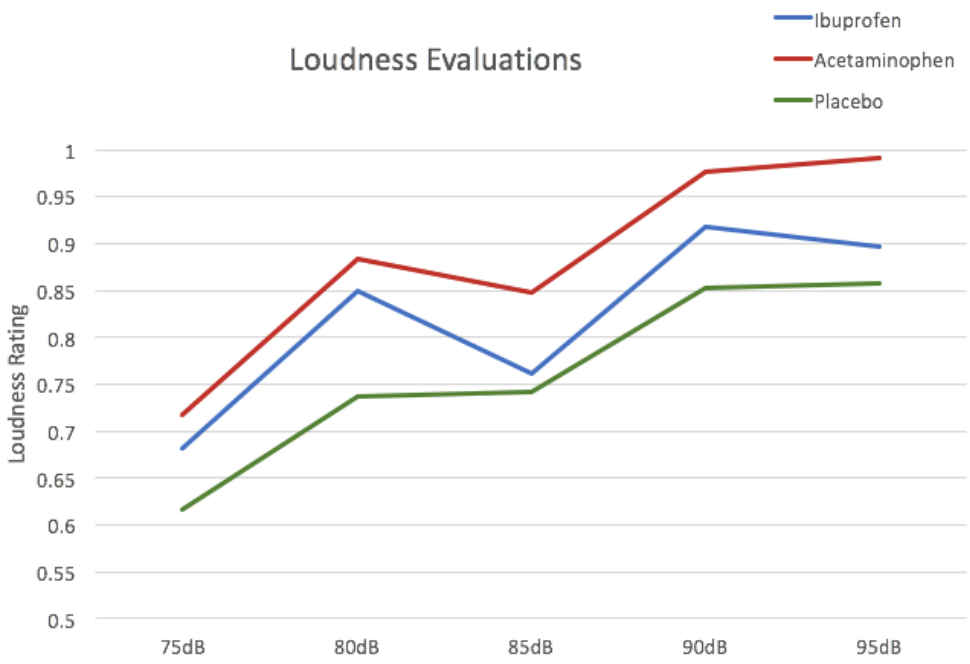


Figure 8: Average ratings of loudness for each decibel level, by drug.

For ratings of loudness, a 0 represents ratings of "Quiet" and a 1 represents ratings of "Loud." Overall, participants found the white noise bursts to be loud, whether they were on placebo (M=.76), ibuprofen (M=.82), or acetaminophen (M=.88). There was a main effect of noise: $F(4, 420)=59.67$, $p<.001$. There was no significant main effect of drug or an interaction of noise and drug.

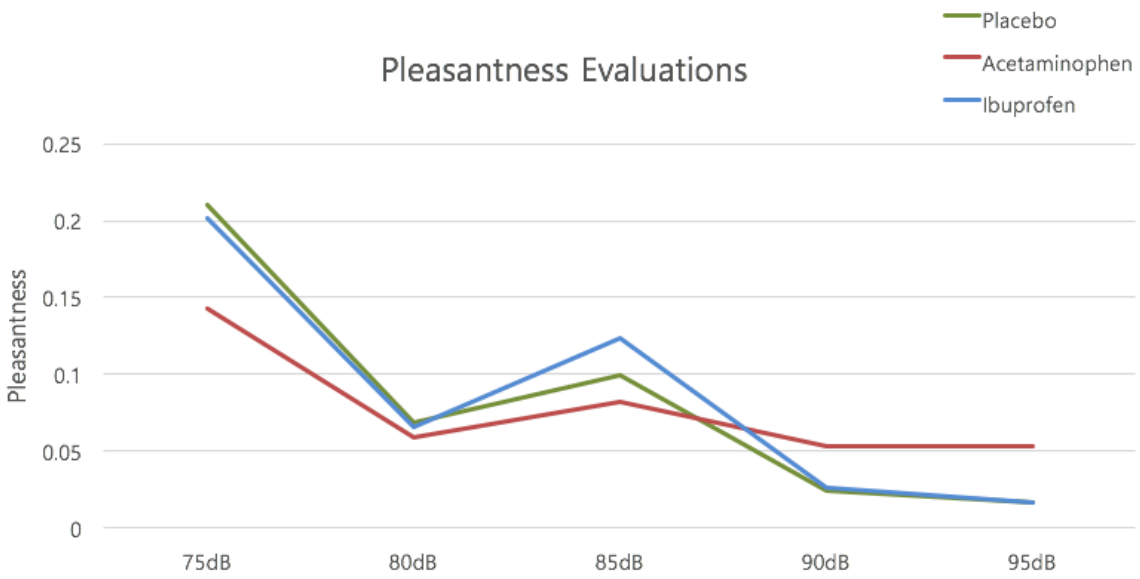


Figure 9: Average ratings of pleasantness for each decibel level, by drug.

For ratings of pleasantness, a rating of 0 would be "Unpleasant" and a rating of 1 would be "Pleasant." Overall, participants found the white noise bursts to be unpleasant, whether they were on placebo (M=0.083), ibuprofen (M=0.087), or acetaminophen (M=0.078). There was a main effect of noise: $F(4, 420)=42.88$, $p<.001$. There was also a significant interaction of noise and drug: $F(8, 420)=2.15$, $p=.03$. We can see from the results that the participants who took acetaminophen both rated quieter decibel levels as less pleasant and rated louder decibel levels as more pleasant as compared to those participants who took placebo or ibuprofen.

### *D. Mental Rotation Task*

On this task, participants indicated which two (of four) images represented an accurate rotation of the target image. There were 10 trials of this task, presented simultaneously on paper forms. The task was scored such that participants get one point for

getting both answers per trial correct, and zero points for any incorrect response on an item. There was a significant main effect of Drug, $F(2,305)=3.15$, $p=.044$ on performance on the Mental Rotation Task. A post-hoc Tukey test revealed a significant difference only between the ibuprofen and acetaminophen groups, $p=.05$.

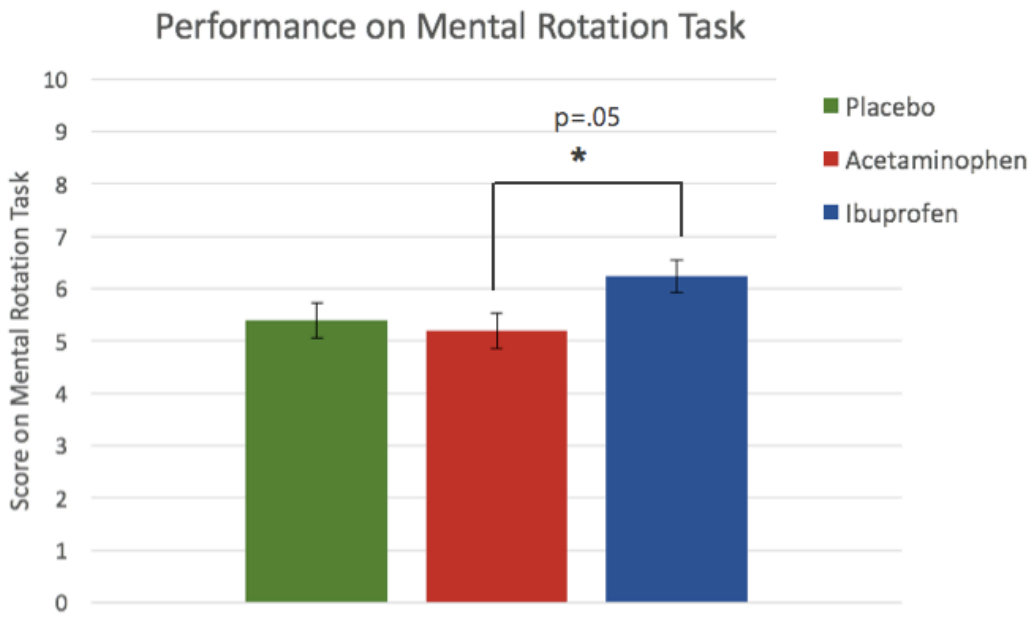


Figure 10: Results of the Mental Rotation Task.

## IV. Discussion

In summation: we found that acetaminophen and ibuprofen did exert an influence on intergroup bias, just in the opposite direction that we had predicted. We saw significant ingroup positivity for the faces generated by participants who had taken either of those medications. In the White Noise Evaluation task, aimed at determining the medications' effect on affective evaluations, we found the predicted acetaminophen blunting effect which replicated previous research. There was no effect of medication on the evaluations of how loud the noises were, however.

The results of the Mental Rotation Task, evaluating visual cognition, showed no significant differences from placebo, but a significant difference between ibuprofen and acetaminophen, such that performance on acetaminophen was blunted compared to ibuprofen. While we did not impose any time-limit on our participants for completing this task, it is possible that the stress of performing the Mental Rotation Task could have had a mitigating effect on performance. This task is often used in research on stereotype threat, and while we offered up no information on that fact, it's possible that participants may be familiar with it in the context of testing gender differences on spatial reasoning ability.

Based on the current results, we can confirm that acetaminophen has a blunting effect on the evaluation of pleasantness of stimuli in a task which explicitly asks for such an evaluation. But our prediction – based on preliminary results from a study conducted at Ohio State University (Ratner, unpublished) – that acetaminophen would also blunt the evaluations of pleasantness which underlie the selection of ingroup member faces did not bear the expected fruit. Because of the unexpected findings in favor of greater ingroup positivity, it is

unclear what conclusions to draw at this time about the potential influence of blunted affective evaluations on ingroup positivity and the mental representations of faces.

One potential reason for the difference in the results from the study run at Ohio State and the current study may be that the current study utilized commercially-available versions of the medications, whereas the study at Ohio State University used mediations that were compounded at a private pharmacy. Due to the safeguards and standards for medication it is unlikely that anything about the active ingredients – acetaminophen and ibuprofen – were variable, but potentially some of the inert ingredients could have made a difference.

Another reason for the difference in results from study to study may have to do with drug absorption, if participants were less-than-truthful about the last time they ingested a large meal before the study session, for example. This would affect drug absorption. However, the results of the pleasantness ratings in the White Noise Evaluation task allow us to infer that at least the acetaminophen was being absorbed to the point that we could replicate the results from Mischowski and colleagues. Since they did not use ibuprofen we can't state anything definitive about its likelihood of absorption based on that task alone, but due to the random assignment of the drugs it is unlikely that those subjects who took ibuprofen happen to have also engaged in everyday activities that would limit medication absorption.

Our results present many interesting questions that are ripe for future study, particularly as we seek to find out more about ibuprofen's influence on these psychological processes since that medication has been the subject of far less research than acetaminophen, but it's prevalence of use makes it the second most-taken drug in the country. Intentionally altering our perceptions of physical pain with over-the-counter medications can be creating

unintentional side-effects on our more basic psychological mechanisms underlying our social evaluations. Due to both the prevalence of use of these medications, and the scope of the problems resulting from intergroup biases, further work on the intersection of these behaviors represents an important and practical research program.

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# Appendix

## A. Full Text Trait Rating Data, with Means and Standard Deviations

1. Trustworthy

There was a significant main effect of both Drug, $F(2,200)=34.10$, $p<.001$, and Group, $F(1,100)=4.86$, $p=.03$ on ratings of Trustworthiness. The interaction of Drug and Group was also significant, $F(2, 200)=72.37$, $p<.001$. Paired t-tests revealed significant differences favoring Placebo-Ingroup ($M=3.71$, $SD=1.28$) over Placebo-Outgroup ($M=3.06$, $SD=1.31$), $t(100)=4.13$, $p<.001$, Acetaminophen-Ingroup ($M=4.73$, $SD=1.29$) over Acetaminophen-Outgroup ($M=3.23$, $SD=1.33$), $t(100)=8.96$, $p<.001$, and Ibuprofen-Ingroup ($M=4.81$, $SD=1.29$) over Ibuprofen-Outgroup ($M=3.30$, $SD=1.45$), $t(100)=7.44$, $p<.001$.

2. Attractive

There was a significant main effect of Drug, $F(2,200)=79.08$, $p<.001$ on ratings of Attractiveness. The interaction of Drug and Group was also significant, $F(2, 200)=73.38$, $p<.001$. Paired t-tests revealed significant differences favoring Placebo-Ingroup ($M=3.85$, $SD=1.31$) over Placebo-Outgroup ($M=3.43$, $SD=1.36$), $t(100)=3.01$, $p=.003$, Acetaminophen-Ingroup ($M=4.79$, $SD=1.28$) over Acetaminophen-Outgroup ($M=2.99$, $SD=1.23$), $t(100)=11.36$, $p<.001$, and Ibuprofen-Ingroup ($M=4.89$, $SD=1.35$) over Ibuprofen-Outgroup ($M=3.02$, $SD=1.25$), $t(100)=10.49$, $p<.001$.

3. Dominant

There were significant main effects of both Drug, $F(2,200)=12.57$, $p<.001$, and Group, $F(1,100)=9.92$, $p=.002$, on ratings of Attractiveness. The interaction of Drug and Group was also significant, $F(2, 200)=11.53$, $p<.001$. Paired t-tests revealed significant differences favoring Placebo-Outgroup ($M=5.15$, $SD=1.30$) over Placebo-Ingroup ($M=4.31$, $SD=1.26$) $t(100)= -5.466$, $p<.001$, Acetaminophen-Outgroup ($M=4.88$, $SD=1.44$) over Acetaminophen-Ingroup ($M=4.23$, $SD=1.31$),

t(100)= -3.13, p=.001, and Ibuprofen-Outgroup (M=4.79, SD=1.39) over Ibuprofen-Ingroup (M=4.13, SD=1.27), t(100)= -3.4, p=.001.

4. Caring

There was a significant main effect of both Drug, F(2,200)=62.706, p<.001, and Group, F(1,100)=4.81, p=.03 on ratings of Caring. The interaction of Drug and Group was also significant, F(2, 200)=63.95, p<.001. Paired t-tests revealed significant differences favoring Placebo-Ingroup (M=3.62, SD=1.29) over Placebo-Outgroup (M=2.92, SD=1.38), t(100)=4.51, p<.001, Acetaminophen-Ingroup (M=4.60, SD=1.35) over Acetaminophen-Outgroup (M=2.91, SD=1.21), t(100)=10.11, p<.001, and Ibuprofen-Ingroup (M=4.81, SD=1.29) over Ibuprofen-Outgroup (M=3.30, SD=1.45), t(100)=7.44, p<.001.

5. Confident

There was a significant main effect of both Drug, F(2,200)=11.10, p<.001, and Group, F(1,100)=6.87, p=.01 on ratings of Confidence. The interaction of Drug and Group was also significant, F(2, 200)=33.18, p<.001. Paired t-tests revealed significant differences favoring Acetaminophen-Ingroup (M=4.91, SD=1.16) over Acetaminophen-Outgroup (M=4.31, SD=1.23), t(100)=3.88, p<.001, and Ibuprofen-Ingroup (M=5.49, SD=1.18) over Ibuprofen-Outgroup (M=4.31, SD=1.39), t(100)=6.34, p<.001. There was no significant difference between Placebo-Ingroup and Placebo-Outgroup.

6. Emotionally Stable

There was a significant main effect of Drug, F(2,200)=42.34, p<.001 on ratings of Emotional Stability. The interaction of Drug and Group was also significant, F(2, 200)=55.70, p<.001. Paired t-tests revealed significant differences favoring Placebo-Ingroup (M=3.98, SD=1.28) over Placebo-Outgroup (M=3.50, SD=1.36), t(100)=3.23, p=.002, Acetaminophen-Ingroup (M=5.04, SD=1.22)

over Acetaminophen-Outgroup (M=3.57, SD=1.31), t(100)=7.69, p<.001, and Ibuprofen-Ingroup (M=5.08, SD=1.19) over Ibuprofen-Outgroup (M=3.48, SD=1.36), t(100)=8.64, p<.001.

7. Responsible

There was a significant main effect of both Drug, F(2,200)=22.06 p<.001, and Group, F(1,100)=6.47, p=.013 on ratings of Trustworthiness. The interaction of Drug and Group was also significant, F(2, 200)=31.91, p<.001. Paired t-tests revealed significant differences favoring Placebo-Ingroup (M=4.17, SD=1.24) over Placebo-Outgroup (M=3.75, SD=1.34), t(100)=2.78, p=.007, Acetaminophen-Ingroup (M=5.03, SD=1.08) over Acetaminophen-Outgroup (M=3.86, SD=1.11), t(100)=8.34, p<.001, and Ibuprofen-Ingroup (M=4.72, SD=1.19) over Ibuprofen-Outgroup (M=3.76, SD=1.23), t(100)=5.36, p<.001.

8. Intelligent

There was a significant main effect of Drug, F(2,200)=31.05, p<.001 on ratings of Intelligence. The interaction of Drug and Group was also significant, F(2, 200)=20.93, p<.001. Paired t-tests revealed significant differences favoring Placebo-Ingroup (M=4.50, SD=1.14) over Placebo-Outgroup (M=4.21, SD=1.16), t(100)=2.26, p=.026, Acetaminophen-Ingroup (M=4.98, SD=1.14) over Acetaminophen-Outgroup (M=4.09, SD=1.16), t(100)=5.93, p<.001, and Ibuprofen-Ingroup (M=5.07, SD=1.13) over Ibuprofen-Outgroup (M=4.02, SD=1.14), t(100)=7.34, p<.001.

9. Sociable

There was a significant main effect of Drug, F(2,200)=57.07, p<.001 on ratings of Sociability. The interaction of Drug and Group was also significant, F(2, 200)=110.56, p<.001. Paired t-tests revealed significant differences favoring Placebo-Ingroup (M=3.66, SD=1.25) over Placebo-Outgroup (M=3.03, SD=1.38), t(100)=4.26, p<.001, Acetaminophen-Ingroup (M=4.81, SD=1.29) over Acetaminophen-Outgroup (M=3.37, SD=1.37), t(100)=8.96, p<.001, and Ibuprofen-Ingroup (M=5.40, SD=1.15) over Ibuprofen-Outgroup (M=3.18, SD=1.36), t(100)=12.40, p<.001.

10. Aggressive (reverse scored)

There was a significant main effect of both Drug, $F(2,200)=63.15$, $p<.001$, and Group, $F(1,100)=5.92$, $p=.017$ on ratings of Aggressiveness. The interaction of Drug and Group was also significant, $F(2, 200)=79.52$, $p<.001$. This trait was reverse scored such that higher scores equate to less Aggressiveness; paired t-tests revealed significant differences favoring Placebo-Outgroup ($M=5.21$, $SD=1.31$) over Placebo-Ingroup ($M=4.03$, $SD=1.31$) $t(100)= -6.74$, $p<.001$, Acetaminophen-Outgroup ($M=4.83$, $SD=1.34$) over Acetaminophen-Ingroup ($M=3.20$, $SD=1.45$), $t(100)= -7.98$, $p<.001$, and Ibuprofen-Outgroup ($M=4.82$, $SD=1.42$) over Ibuprofen-Ingroup ($M=2.78$, $SD=1.34$), $t(100)= -11.25$, $p<.001$.

11. Mean (reverse scored)

There was a significant main effect of both Drug, $F(2,200)=49.18$, $p<.001$, and Group, $F(1,100)=5.36$, $p=.023$ on ratings of Meanness, reverse scored such that higher scores equate to less Meanness. The interaction of Drug and Group was also significant, $F(2, 200)=78.39$, $p<.001$. This trait was reverse scored such that higher scores equate to less Meanness; paired t-tests revealed significant differences favoring Placebo-Outgroup ($M=4.95$, $SD=1.44$) over Placebo-Ingroup ($M=3.93$, $SD=1.49$) $t(100)= -5.75$, $p<.001$, Acetaminophen-Outgroup ($M=4.59$, $SD=1.37$) over Acetaminophen-Ingroup ($M=2.86$, $SD=1.45$), $t(100)= -9.03$, $p<.001$, and Ibuprofen-Outgroup ($M=4.61$, $SD=1.61$) over Ibuprofen-Ingroup ($M=2.50$, $SD=1.43$), $t(100)= -9.86$, $p<.001$.

12. Weird (reverse scored)

There was a significant main effect of Drug, $F(2,200)=46.14$, $p<.001$ on ratings of Weirdness. The interaction of Drug and Group was also significant, $F(2, 200)=24.75$, $p<.001$. This trait was reverse scored such that higher scores equate to less Weirdness; paired t-tests revealed significant differences favoring Acetaminophen-Outgroup ($M=4.00$, $SD=1.76$) over Acetaminophen-Ingroup ($M=2.40$, $SD=1.47$), $t(100)= -8.71$, $p<.001$, and Ibuprofen-Outgroup ($M=3.83$, $SD=1.80$) over

Ibuprofen-Ingroup (M=2.41, SD=1.48), t(100)= -6.71, p<.001. There was no significant difference between Placebo-Ingroup and Placebo-Outgroup.

13. Unhappy (reverse scored)

There was a significant main effect of Drug, F(2,200)=57.90, p<.001 on ratings of Unhappiness. The interaction of Drug and Group was also significant, F(2, 200)=81.65, p<.001. This trait was reverse scored such that higher scores equate to less Unhappiness; paired t-tests revealed significant differences favoring Placebo-Outgroup (M=4.85, SD=1.51) over Placebo-Ingroup (M=4.31, SD=1.48), t(100)= -3.13, p=.002, Acetaminophen-Outgroup (M=4.72, SD=1.34) over Acetaminophen-Ingroup (M=3.24, SD=1.32), t(100)= -7.73, p<.001, and Ibuprofen-Outgroup (M=4.59, SD=1.37) over Ibuprofen-Ingroup (M=2.30, SD=1.18), t(100)= -12.22, p<.001.