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Friend Effects Framework: contrastive and hierarchical processing in cheerleader effects

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Abstract

Cheerleader effects, group attractiveness effects, and divisive normalization are all characterized by faces appearing more attractive when seen within a group. However, it is possible that your friends could have a detrimental effect upon your attractiveness too: if these group effects arose partly as a contrastive process between your face and your friends, then highly attractive friends may diminish your attractiveness. We confirm this hypothesis across two experiments by showing that the presence of highly attractive friends can indeed make you appear less attractive (i.e., a reverse cheerleader effect), suggesting friend effects are driven in part by a contrastive process against the group. However, these effects are also influenced by your own attractiveness in a fashion that appears consistent with hierarchical encoding, where less attractive targets benefit more from being viewed in an increasingly unattractive group than attractive targets. Our final experiment demonstrates that the company of others not only alters our attractiveness, but also induces shifts in how average or distinctive a target face appears too, with these averageness effects associated with the friend effects observed in our first experiment. We present a Friend Effects Framework within which 'friend effects' is an umbrella term for the positive (e.g., cheerleader effects, group attractiveness effects) and negative (i.e., the reverse cheerleader effect) ways in which hierarchical encoding, group contrastive effects, and other influences of friends can have on your attractiveness.

Keywords: Face; Facial attractiveness; Ensemble coding; Cheerleader effect; Averageness

1. Introduction

Faces are more attractive when viewed in a group versus being rated alone in isolation (Carragher et al., 2019; Furl, 2016; van Osch, Blanken, Meijs, & van Wolferen, 2015; Walker & Vul, 2014; Ying, Burns, Lin, & Xu, 2019), with some authors and popular media outlets reporting that you should surround yourself with friends to enhance your beauty (e.g., Walker & Vul, 2014). Psychologists have given these effects many names, e.g., The Group Attractiveness Effect (van Osch et al., 2015), where groups are rated as more attractive than the mean of their individual members, The Cheerleader Effect (Walker & Vul, 2014), where faces seem more attractive when viewed in a group than in isolation, and Divisive Normalization (Furl, 2016), where the presence of a third face will make one face of a pair suddenly appear more attractive than its paired counterpart. Despite these different names, all of these effects share the same basic principle whereby the presence of others can boost our attractiveness.

However, what if your 'cheerleading' friends in these images are not always a positive influence, but could instead produce no benefits, or even be detrimental to how attractive you are perceived to be? Indeed, there are rare instances in the cheerleader effect literature where authors have failed to show any positive effects (e.g., Geiselman et al 1984; McDowell & Starratt, 2019; Ojiro et al., 2015; van Osch et al., 2015). This is surprising as the average effect sizes for cheerleader effects are typically medium to very large (e.g., Carragher et al., 2018: mean Cohen's d = .56; 2019: mean Cohen's d = .67; Walker & Vul, 2014: η_p^2 = .197; Ying et al., 2019: η_p^2 = .35). Examining these failures to replicate hint that a lack of variance in the faces in the scene (Jeong & Chong, 2020; Ying et al., 2019; although see Carragher et al., 2019), testing participants in groups where they can see other participants (McDowell & Starratt, 2019), or testing faces of ethnicities that are not your own (Ojiro et al., 2015), may be potential causes, but there are no obviously consistent reasons why some studies fail to find such effects. Here we test some hypotheses that will provide some explanations for these null results. Before introducing these though, we review the three main components that are thought to give rise to cheerleader effects: the social positive effect, the contrast effect and hierarchical encoding. This will help provide some of the context required to easily understand our predictions for the forthcoming experiments.

1.1. Hypothesized Components of the Cheerleader Effect

1.1.1. The Social Positive Effect

We hypothesized that the cheerleader effect may partly occur due to viewers believing the target is more popular when it is surrounded by other faces, hence inducing higher appraisals of attraction due to this popularity (Ying et al., 2019). A similar line of thinking was provided by Carragher and colleagues (Social Inference Effect, 2019) in that viewers may infer positive, unseen social qualities such as friendliness or kindness in the target due to this popularity. Support for the social positive effect has come from paradigms showing that the cheerleader effect still occurs even when the same identity and/or image is used for both the target and the faces in the surrounding group (Carragher et al., 2019; Ying et al., 2019[1]). As the surrounding faces do not differ from the target's characteristics in any way except from simply existing as other faces present in the scene, we can assume that the mere presence of others induces the effect.

However, it is important to note that the presence of others is insufficient to entirely explain cheerleader effects. Using identical images for the target and the group in a scene seems to result in smaller cheerleader effects than using different images of the same identity (Carragher et al., 2019; Ying et al., 2019) or different identities (Carragher et al., 2019; Ying et al., 2019). Indeed, identical images induce a cheerleader effect that is on average 30% (45%, Carragher et al., 2019; 16%, Ying et al., 2019) the size of a cheerleader effect arising from different identities. Similarly, even the presence of non-face stimuli, such as houses, makes a target face appear more attractive than in isolation (Carragher et al., 2019). Variance of visual information provided by the surrounding images must therefore contribute somewhat to the cheerleader effect, in addition to the social positive effect. While much has yet to be discovered about how visual variance in a scene impacts the cheerleader effect, investigators have confirmed that varying group attractiveness certainly has an influence (Ying et al., 2019).

1.1.2. The Contrast Account

In addition to the social positive component, we hypothesized that the cheerleader effect may be partly shaped by a contrast between the target face and its surrounding group (Ying et al.,

[1] We should mention Ying et al., 2019 only found a non-significant trend for a cheerleader effect when using identical faces. We reanalyzed this data based upon Carragher and colleagues' positive findings (2019) using the change in number of attractive responses between baseline and cheerleader condition. Doing so revealed a cheerleader effect in our identical faces condition when reanalyzing our data this way [one-tailed, $t(29) = 1.84$, $p = .038$]. Further well powered replications of this work will hopefully clarify if this effect arises via social inferences (i.e., this face is popular) or if it is a perceptual phenomenon (i.e., via the averaging of certain group qualities, such as the low spatial frequencies, onto the target).

2019), where decreasing group attractiveness leads to larger cheerleader effects, i.e., we look more attractive when we are in the company of unattractive friends, relative to attractive friends, because the comparative options nearby are not particularly attractive. We called this the contrast account and confirmed that the cheerleader effect does indeed linearly decrease as the surrounding group becomes more attractive (Ying et al., 2019).

The cheerleader effect therefore appears shaped in a way that is consistent with a contrast occurring between the target and group; i.e., targets will typically appear more attractive in a highly unattractive, relative to an attractive, group. This is because being compared to a group of unattractive faces is more favorable than having our every flaw magnified against a group of perfect looking supermodels.

However, the size of this contrast effect will also likely vary depending upon the target's own attractiveness relative to the group. For example, an exceptionally attractive face in a group of only moderately attractive individuals will in theory exhibit a larger more positive cheerleader effect than an unattractive target, due to the highly attractive target appearing more attractive relative to the group. The unattractive target by contrast will appear even less attractive. Remarkably, this latter prediction of the contrast account has yet to be fully confirmed. While we do not test this aspect of the contrast hypothesis here due to our experimental design, we wanted to provide a full account of what the contrast hypothesis predicts. This is because it is arguably at odds with the next hypothesised component of the cheerleader effect: the hierarchical account.

1.1.3. The Hierarchical Account

It has been argued that cheerleader effects may occur through hierarchical encoding (e.g., Walker & Vul, 2014; but see Carragher et al., 2019). This hypothesis could be interpreted in a number of possible ways. Here we present two variations, but both make largely identical predictions: unattractive targets should always exhibit more positively directed cheerleader effects relative to attractive targets.

The first interpretation of the hierarchical account argues that faces become more attractive when viewed with others because they are averaged towards the group's mean characteristics via ensemble coding (Brandner et al., 2020; Haberman, & Whitney, 2007; Ji & Hayward, 2020; Maule & Franklin, 2020; Whitney & Leib, 2018; Ying et al., 2020). The human visual system can calculate the mean characteristics of faces in a scene, with this mean typically being more

average and prototypical than the constituent faces it is comprised of (DeBruine et al., 2007; Perrett et al., 1994; Ying et al., 2020). If the target is averaged towards this mean, then it will appear more average looking, smoothing out its distinctive wrinkles and asymmetrical deviations which are unattractive qualities, and as a result, appear more attractive. As unattractive targets contain more atypicalities in their structure than attractive targets (Rhodes & Tremewan, 1996), they will always benefit more from this averaging.

An alternative view is that the human visual system is averaging the actual attractiveness of the faces in a scene together through ensemble statistics, rather than their averageness. As the mean attractiveness of a group of faces averaged together is typically more attractive than the mean of its constituent faces (e.g., DeBruine et al., 2007; Perrett et al., 1994), then biasing the target towards this mean will result in it appearing more attractive. This is because the target takes on the attractive qualities contained within the group's average. Instead of target faces appearing more average in company, they are assimilated into the average of the group's attractiveness. Again, this hypothesis predicts that unattractive faces will benefit more in groups relative to attractive targets because they have the most to gain from being biased towards the group's mean attractiveness.

To illustrate this point, imagine three surrounding friends whose mean attractiveness = 5, but an unattractive target = 1. The average of these four faces is 4, which means a potential boost for the target of 3 (i.e., 4 – 1 = 3). By contrast, a more attractive target (i.e., a 4) would gain a smaller benefit from being in the group (e.g., the average of 4.75 – 4 = .75). The hierarchical account therefore suggests that as a target's attractiveness decreases, then so too will the benefits of the cheerleader effect increase in tandem.

1.1.4. Competition between the Hierarchical and Contrast Accounts?

The hierarchical and contrast hypotheses predict competing ways in which the target's own attractiveness may influence the cheerleader effect. As mentioned, the contrast hypothesis suggests highly attractive targets should gain a larger cheerleader effect when viewed in an unattractive group than what an unattractive target would gain. This is because the attractive target's positive qualities should become more highly prized in an unattractive group, whereas an unattractive face appears little more attractive in comparison to other unattractive alternatives in the group.

The hierarchical account stands in direct conflict with the above prediction. In this

perspective, an unattractive target would benefit from being viewed in an unattractive group as the group's average will be more attractive than both the target and the group's constituent faces. An attractive target, however, may find its attractiveness diminishing because the average of a group of unattractive faces is less attractive than that of attractive faces (Ying et al., 2020). This hypothesis predicts that while group attractiveness may vary, unattractive faces will always benefit more in a group relative to attractive faces.

For example, in a highly attractive group, an unattractive target will be biased positively towards the group's attractiveness more so than an attractive target. If a group only exhibits a medium level of attractiveness, then the unattractive target will still benefit in such a group, while an unattractive target may gain little, or could even be diminished if the group's mean is less than that of the target[1]. According to the hierarchical account, while the group's attractiveness may vary, its key prediction remains the same: less attractive faces will benefit more in a group than attractive faces. In the current study, we test this and a number of other key predictions arising from the contrast and hierarchical accounts of the cheerleader effect. Moreover, we also provide a framework in which we can understand the cheerleader effect's influences and related phenomena (Figure 5).

1.2.The Current Study: Testing the Cheerleader Effect Hypotheses

1.2.1. Experiment 1A and 1B: A Reverse Cheerleader Effect

If cheerleader effects are partially driven by a contrastive process between the rated face and its surrounding friends (see Ying et al., 2019; Kenrick & Gutierres, 1980; Nagy et al., 2012; Re et al., 2014; Wedell et al., 1986), then highly attractive friends may actually diminish your own beauty, thereby producing a reverse cheerleader effect. This effect is predicted by our prior work where we showed a negative relationship between the size of the cheerleader effect and the attractiveness of the surrounding group (Ying et al., 2019); i.e., increasing group attractiveness led to smaller cheerleader effects. We therefore wondered if highly attractive faces could abolish, or even reverse, cheerleader effects. Such a result would have obvious practical implications for how we might want to present ourselves on social media and in dating apps, but could also help explain why cheerleader effects are not always replicated (McDowell & Starratt, 2019; Ojiro et al., 2015). We therefore test this hypothesized reverse cheerleader effect in our first (Experiment

[1] It is worth reminding the reader at this point that the social positive effect likely induces a large positive shift in attractiveness for all faces, and it is from this point that we envisage hypothesised contrast or hierarchical components may be further exerting their influence (Ying et al., 2019).

1A) and second (Experiment 1B) experiments: the first using a two-alternative forced choice task similar to our prior work (Ying et al., 2019), and then a Likert scale rating task in our second study which is more common in cheerleader research (e.g., Carragher et al., 2019; Walker & Vul, 2014). By using these dual approaches, we can confirm reverse cheerleader effects are robustly observed across diverse paradigms.

1.2. Experiment 1A and 1B: Testing the Hierarchical and Contrast Accounts

The hierarchical account suggests that as a target's attractiveness decreases, then so too will the benefits of the cheerleader effect increase in tandem. If the target is an unattractive face, then it will gain more being biased towards a highly attractive group, whereas an attractive target will gain little. Conversely, an unattractive target may gain little being viewed in an unattractive group, while a highly attractive target may actually appear less attractive. As mentioned earlier, irrespective of group attractiveness, the unattractive targets will always gain more, or lose less, when viewed in groups relative to attractive targets. We intend to test this key prediction across groups of faces that are varied in attractiveness. If we find such an effect, then it will support a key prediction of the hierarchical account.

The contrast hypothesis conflicts with this suggestion, predicting a different direction of effects: attractive faces will benefit more in an unattractive group because they appear more attractive relative to the alternatives in the scene. Also, attractive faces will benefit little in attractive groups, and unattractive faces will look less attractive. While we designed Experiment 1B to test the hierarchical account, it will also help indicate if the contrast hypothesis is supported too (e.g., attractive faces gain more in an unattractive group).

1.3.Experiment 2: Do target faces appear more average during cheerleader effects?

Finally, no work has shown cheerleader effects to be present in face trait judgments beyond facial attractiveness and trustworthiness (Carrager et al., 2021), nor has anyone yet answered why target faces appear more attractive in the company of friends. While Experiment 1B will go a long way to answering how the target's attractiveness is influencing cheerleader effects, it will not tell the whole story. Cheerleader effects may be a perceptual phenomenon that occurs due to changes in how average a target face appears (Little, Jones, & DeBruine, 2011; Langlois, Roggman, & Musselman, 1994; O'Toole, Price, Vetter, Bartlett, & Blanz, 1999; Perrett, May, & Yoshikawa, 1994; Rhodes & Tremewan, 1996; Valentine, Darling, & Donnelly, 2004). If this is true, then we should expect target faces to appear more average (i.e., an averageness cheerleader

effect) to a viewer when viewed in groups versus isolation. By running Experiment 1A again on the same participants, but this time asking participants to rate the targets on the basis of how average they appear, we should find that these effects correlate with the magnitudes of the attractiveness cheerleader effects we observe in Experiment 1A. Moreover, such a result will confirm that cheerleader effects are not solely restricted to attractiveness, trustworthiness or sexual interest (Carragher et al., 2021; McDowell & Starratt, 2019; Walker & Vul, 2014), but can extend into other trait judgments, such as averageness.

Of course, it is possible that targets may appear more average because they are becoming more attractive. This means that even if we do observe an averageness cheerleader effect, and show it to be related to the attractiveness cheerleader effect, we cannot be certain if one effect is inducing the other. It may even be the case that cheerleader effects can simply occur for attractiveness *and* averageness, and that any link between the two is coincidental. However, such a result would at least appear consistent with the hypothesis that cheerleader effects may arise by making faces appear more average. We therefore invited back the same participants from Experiments 1A and 1B to test these possibilities in Experiment 2.

To summarize, in our first two experiments we tested whether highly attractive friends could result in a detrimental reverse cheerleader effect. In the second of these experiments, we also aimed to answer whether the hierarchical account of the cheerleader effect was correct. Finally, in our third experiment, we examined whether averageness cheerleader effects are related to attractiveness cheerleader effects.

Owing to our predicted reverse cheerleader effect potentially making faces appear less attractive, and to take into account other positive effects a surrounding group can have (e.g., group attractiveness effects, and divisive normalization), we introduce a conceptual framework within which to understand these effects (Figure 5: Discussion). In this framework (and the rest of this paper), we refer to ‘friend effects’ as an umbrella term that includes the positive (e.g., the cheerleader effect, group attractiveness effect) and our predicted negative (e.g., our hypothesized reverse cheerleader effect) effects that faces in a scene can have on our attractiveness[1]. Moreover, we highlight additional contextual effects from attractiveness research that may be more broadly related.

[1] Please note that our use of the word ‘friends’ should not be taken to mean that we are literally inferring the faces surrounding a target are actually their friends. Instead, we are merely using the term to friends to describe the faces surrounding the target.

Experiments 1A and 1B

Methods

Participants

The same group of thirty-four Chinese students (14 males, 19 females; mean age of 19.6 years) from Soochow University, with normal or corrected-to-normal vision, participated in Experiments 1A and 1B during the same experimental session. They were also invited back for Experiment 2 in a separate session. We had aimed to recruit 30 participants as prior work had shown this would yield high power $1 - \beta = 1$ (Ying et al., 2019), however, five additional participants signed up before the registration system was closed so we tested them anyway, although one dropped out after pre-testing (see below). As developmental prosopagnosia is associated with severe, lifelong impairments in face processing (Bate & Tree, 2017; Bate et al., 2014; Burns et al., 2014, 2017a, 2017b; Wilcockson et al., 2020), and qualitative atypicalities in face perception (Burns et al., 2014, 2017b) including ensemble coding (Robson et al., 2017; although see Leib et al., 2012), all participants had to report no trouble with faces: a fundamental trait of prosopagnosia. Participants were also naïve to the purpose of the experiment and provided informed consent, with ethics approved by the Ethics Committee at Soochow University, China.

Stimuli

In order to find sufficiently attractive, but unfamiliar, face stimuli, we searched three ethnic Chinese face databases: the Nanyang Facial Emotional Expression Database (N-FEE; Yap, Chan, & Christopoulos, 2016), the Taiwanese Facial Expression Image Database (TFEID; Chen & Yen, 2007) and an unnamed database used by Wang, Yao and Zhou (2015). Due to publishing

restrictions, we use faces from the KDEF Database (Lundqvist, Flykt, & Öhman, 1998) in our figures for illustrative purposes. Selected faces had to be clearly viewable, female (as prior work has shown female faces elicit cheerleader effects: e.g., Carragher et al., 2019; Walker & Vul, 2014; Ying et al., 2019), and easily identifiable as female. In total, 45 faces from these databases were selected by the research team to be potentially used as the surrounding 'friend' faces in all experiments, and also the rated target faces in Experiment 1B. All faces were cropped with an oval mask leaving only the internal region visible. Faces were then grayscaled and luminance equalised by the SHINE toolbox (Willenbockel et al., 2010).

Our first experiment was a forced choice task using seven morph continua faces as the targets (i.e., those rated for attractiveness) that ranged in incremental steps from unattractive to attractive (for details, see Ying et al., 2020). These faces were created using an attractive face and an unattractive face taken from the N-FEE database, and were different identities from those that comprised the 45 faces taken from the three different databases.

We selected the surrounding faces ('the friends') based on a pre-test rating study on the same participants around two weeks before the experiment (paradigm adapted from Rhodes & Jeffery, 2006; Ying et al., 2020). During the pre-test, participants were asked to rate the 45 faces for facial attractiveness on a 7-point scale (1 for least attractive and 7 for most attractive). Please note that it is unlikely that the difference between 6 and 7 on this scale is equal to the distance between 4 and 5. We therefore believe that while the magnitudes of effects across this scale may vary to some small extent on this basis, the direction of observed effects are unlikely to change.

Faces were presented individually in a random sequence, four times (on a 1-7-point scale, 1 for least attractive and 7 for most attractive). We then selected four attractive [M_{ATT} = 5.46;

M_{ATT1} = 5.77, *SD* = .91; M_{ATT2} = 5.76, *SD* = .91; M_{ATT3} = 5.23, *SD* = 1.01; M_{ATT4} = 5.06, *SD* = 1.11] and four unattractive faces [M_{UNA} = 2.30; M_{UNA1} = 2.24, *SD* = .98; M_{UNA2} = 2.27, *SD* = .80; M_{UNA3} = 2.32, *SD* = .82; M_{UNA4} = 2.35, *SD* = .98] as 'friend' stimuli for Experiments 1A and 1B, based on the consensus from 35 participants (including the one who dropped out afterwards). Another 14 faces from the remaining 37 faces were selected by the experimenters to be used as targets (i.e., the faces that would be rated by participants) in the direct rating task in Experiment 1B. Faces were selected so that they would be broadly distributed across the range of attractiveness ($M_{most\ attractive}$ = 4.91, *SD* = 1.22; $M_{least\ attractive}$ = 2.92, *SD* = 1.22). Note that, the attractive and unattractive surrounding faces (i.e., the 'friends') are always more extreme than the target faces, i.e, more attractive or unattractive respectively.

Apparatus

Face stimuli were presented on a 22-inch ASUS PG278Q LCD monitor (spatial resolution 2560×1440 pixels, refresh rate 120 Hz; see Zhang, Li, Miao, He, Zhang, & Zhang, 2018). The monitor was controlled by a computer (Linux OS) running Matlab R2016a (MathWorks) via Psychtoolbox (Brainard, 1997; Pelli, 1997). During the experiment, participants sat in an adjustable chair, with their chins rested on a chin rest which was placed at 53 cm away from the monitor, and each pixel subtended .025° on the screen.

Procedure

The general procedure for this experiment was adapted from previous experiments testing the cheerleader effect and ensemble coding of facial attractiveness (Ying et al., 2019, 2020). There were two experiments, with the first being a 2-Alternative forced choice task (2AFC;

Experiment 1A) where participants judged morph continua targets as attractive or unattractive. The second study (Experiment 1B) was a direct rating task where the same participants rated target faces using a Likert attractiveness scale. Also, there were three groups of four surrounding faces (i.e., 'friends' of the target), each of which reflected the attractiveness levels of the faces in that group: four attractive friends (ATT), four unattractive friends (UNA), four 'mixed' friends comprising of two attractive and two unattractive faces (MIX) from the attractive and unattractive face groups, and a fourth no friend baseline condition. Thus, there were four experimental blocks (i.e., ATT, MIX, UNA, No Friend Baseline) in each experiment where only those friends (or lack of) would be presented; e.g., in the UNA block, only unattractive faces would surround the target on every trial. These blocks were the same in Experiments 1A and 1B. The four faces were presented 3.10° away from the central fixation cross, in a square fashion surrounding the central test face (Figure 1). All faces were displayed at a size of 3.28° × 4.23°

Each trial commenced with a 0.5s ~ 1s interval (Figure 1). After that, the test face appeared with (or without) the four surrounding faces for 1s. After they disappeared, the participants were asked to indicate the attractiveness of the test face either by 2AFC (attractive or unattractive) in Experiment 1A or direct rating (on a 1-7-point scale, 1 for least attractive and 7 for most attractive) in Experiment 1B.

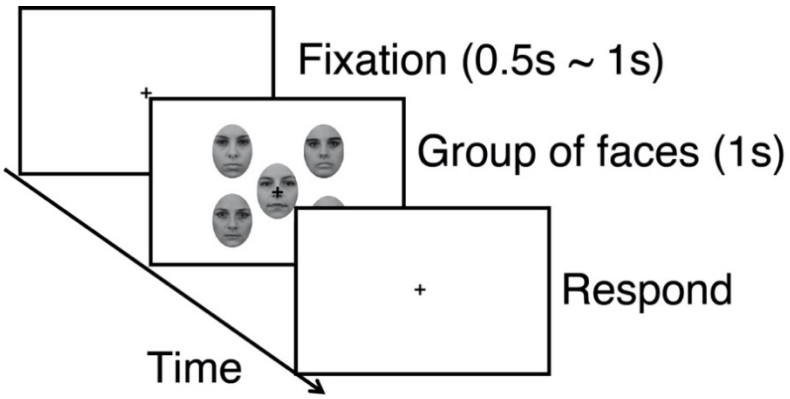

Figure 1. The trial sequence of the experiment. The faces are from the KDEF face database for demonstration purposes (faces are AF01NES, AF06NES, AF08NES, and AF20NES). Participants fixated on the central fixational cross throughout the whole experiment. After a 0.5~1s inter-trial interval, the test face appeared with four surrounding 'friends' for 1s. The participants were then asked to report the attractiveness of the central face either by forced choice (Experiment 1A) or direct rating (Experiment 1B).

In the 2AFC task in Experiment 1A, the test faces were taken from the previously described morph continua (the same test faces from Ying et al., 2020). In each individual attractiveness condition in Experiment 1A, participants judged the attractiveness of each of the seven test faces 12 times in a randomized trial order. During Experiment 1B, each trial presented one of the 14 test faces selected from the 45 faces initially rated during the pre-test rating study. These 14 faces were presented in random sequence and repeated four times across each block.

Data Analysis

For the 2AFC task, the proportion of 'attractive' responses from each participant was sorted. These responses were then plotted against the attractiveness unit for each of the test faces to form a psychometric curve (Wichmann & Hill, 2001). Friend effects were measured by subtracting the point of subjective equality (PSE) in the no friend baseline condition from each of the friend conditions. Thus, for Experiment 1A, negative values will reflect positive friend effects (i.e., a cheerleader effect), whereas a positive change will indicate friends made the target seem less attractive (i.e., a reverse cheerleader effect). To make it easier to inspect, and to

maintain consistency with the results of Experiment 1B (where positive friend effects are positive values), we invert the y-axis of the figure illustrating the mean friend effects (Figure 2B).

For the direct rating data, we calculated the mean attractiveness ratings of all 14 test faces in each block for each of the 34 participants and subtracted the no friend baseline to generate the ratings shift (i.e., friend effect). In Experiment 1B, a positive shift will reflect a cheerleader effect, whereas a negative change will indicate friends made the target seem less attractive in that condition (i.e., a reverse cheerleader effect).

In Experiment 1B we also tested the relationship between the attractiveness ratings for all targets viewed within a particular group against the targets' ratings in the no group baseline condition using a repeated measures correlation analysis (Bakdash & Marusich, 2017). Unlike the conventional correlation analysis which requires independent data points, the repeated measures correlation allows us to compare multiple non-independent data points from the same participant (i.e., ratings for each of the 14 faces). For example, this analysis allows us to examine how a target's attractiveness influences the magnitude of friend effects, and whether these influences are similar across participants (i.e., in the same direction) within a particular condition (e.g., the attractive group). This will therefore allow us to test whether our hierarchical account of the cheerleader effect is correct (i.e., unattractive faces viewed in a group gain more relative to attractive faces). All statistical analyses were conducted in R 3.4.3 (R Core Team, Vienna, Austria), JASP 0.11.1 (JASP team, 2019) and Matlab R2017b (MathWorks, MA, USA). Data for all experiments can be found on the Open Science Framework (https://osf.io/4gywb/).

Results Experiment 1A: 2-AFC Paradigm

The 2AFC data from all 34 participants were averaged together and shown in Figure 2A. We plotted the proportion of 'attractive' responses as a function of the attractiveness unit of the test faces. A leftward psychometric curve shift relative to the baseline condition would indicate that the test faces are perceived as more attractive in the company of friends: a classic cheerleader effect, with larger shifts indicating stronger effects. From the psychometric functions, it is obvious that the unattractive friends condition (UNA) generated the classic cheerleader effect. However, the attractive friends condition (ATT) made the test faces appear less attractive, indicating the presence of our hypothesized reverse cheerleader effect.

The summary of the friend effects across all friend conditions are shown in Figure 2B. Compared to the no friend baseline PSE, only the unattractive friends generated a significant attractiveness boost [UNA; M = - 9.4%, $t(33)$ = - 4.81, $p < .001$, Cohen's d = 0.83]: the classic cheerleader effect. Mixed attractiveness friends failed to induce any friend effects [MIX; M =

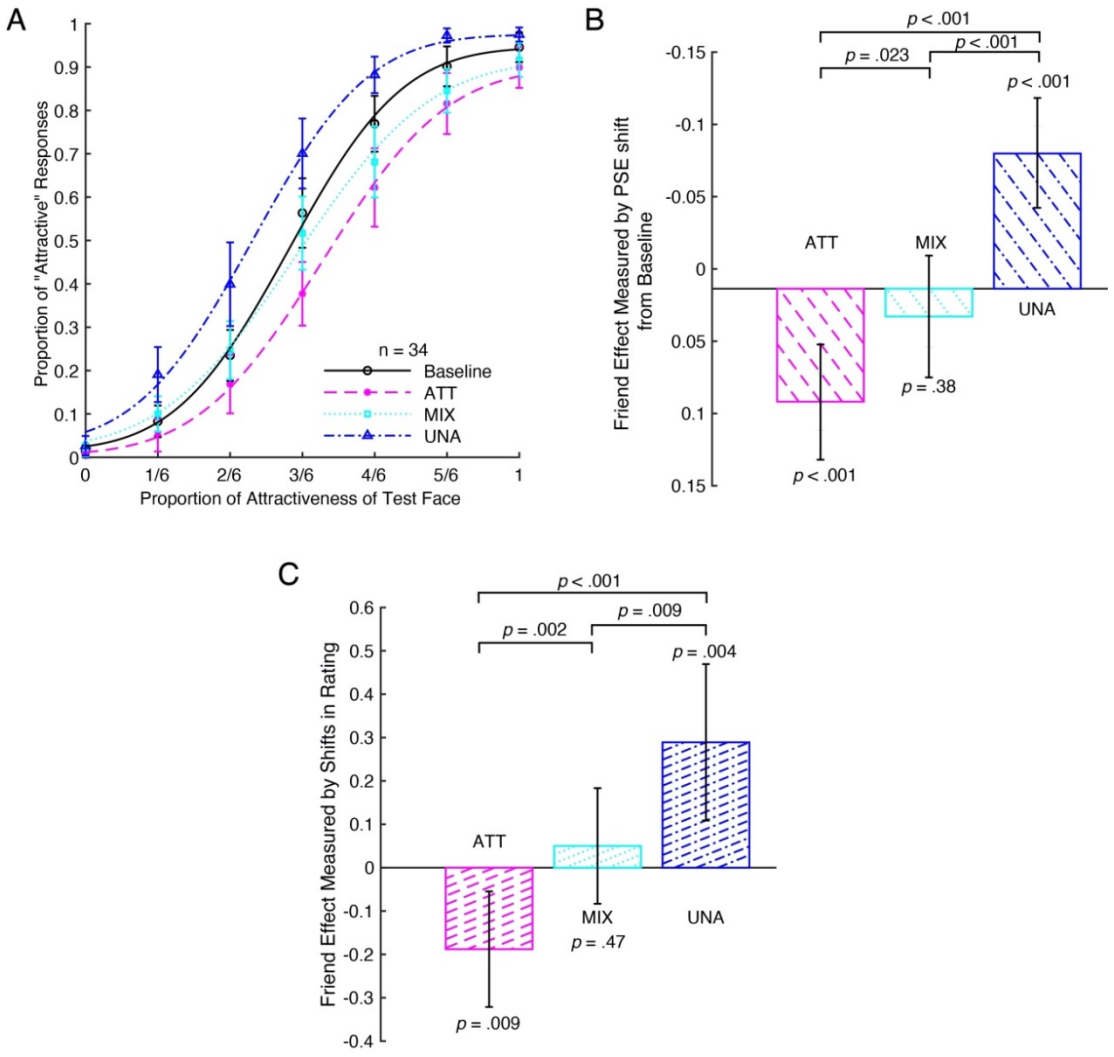

Figure 2. The summarized data for the 2AFC task (panels A and B) and the direct rating task (Panel C). (A) The psychometric functions of all participants' 2AFC Experiment 1A data averaged together and (B) their mean PSE shifts. (C). Summary of the direct rating tasks in Experiment 1B. We see the predicted reverse cheerleader effect in both experiments; i.e., attractive friends (ATT) make the targets appear less attractive (see the *Data Analysis* section for an explanation of the axes). The *p*-values were from the paired sample *t*-tests with Bonferroni corrections and all error bars indicate 95% confidence intervals.

1.9%, $t(33) = .90$, $p = .37$, Cohen's $d = 0.15$]. Attractive friends, by contrast, made the targets appear less attractive relative to the no friend baseline; a novel reverse cheerleader effect [ATT; $M = 7.8\%$, $t(33) = 3.85$, $p < .001$, Cohen's $d = 0.66$]. An ANOVA suggested significant differences between the surrounding friend conditions' [$F(2,66) = 28.74$, $p < .001$, $\eta_p^2 = .47$], with Bonferroni comparisons confirming graded levels of friend effects [i.e., unattractive friends>mixed friends>attractive friends, Figure 2B, all *ps* < .023].

Results Experiment 1B: Direct Ratings Paradigm

First, we wondered if we could replicate the findings of Experiment 1A in our second experiment's direct ratings. Analyses confirmed a similar pattern of results in Experiment 1B (Figure 2C), with the attractive friends condition exhibiting a reverse cheerleader effect, where targets seemed less attractive in the company of attractive friends versus being viewed in isolation [ATT; M = -.19, $t(33)$ = - 2.77, p =.009, Cohen's d = -.48]. Also, no friend effects were observed in the mixed condition [MIX; M = .05, $t(33)$ = .74, p = .46, Cohen's d = .13], but there was a positive cheerleader effect in the unattractive friends condition [UNA; M = .29, $t(33)$ = 3.13, p =.004, Cohen's d = .54]. Comparisons between the size of the cheerleader effects across friend conditions again replicated the graded pattern of results observed in Experiment 1A; i.e., unattractive friends>mixed friends>attractive friends [all ps < .01, all Cohen's d > .47]. Replicating the pattern observed in Experiment 1A, the results of the ANOVA revealed significant differences between the three friend conditions' [Greenhouse-Geisser corrected $F(1.24,16.14) = 61.10$, $p < .001$, $\eta_p^2 = .83$]. Bonferroni comparisons confirmed graded levels of friend effects [i.e., unattractive friends>mixed friends>attractive friends, Figure 2C, all ps < .001].

An open question in friend effects research is whether the target face (i.e., the face being rated) influences the size of the friend effect (Ying et al., 2019). For example, do highly attractive faces benefit less from being in the company of friends than unattractive faces: a key prediction of the hierarchical account. If so, we should observe a significant negative correlation between the size of the friend effect for each target face in a single friend condition, and the face's original attractiveness rating in the baseline condition. We tested this hypothesis by running repeated measures correlations (rmcorr; Bakdash & Marusich, 2017) for each friend condition separately (Figure 3) and found that there were indeed negative correlations across the target faces' attractiveness in the baseline condition, and the size of its friend effect: attractive friends [ATT; r = - .31, p < .001, 95% CI [- .39, - .22]], mixed friends [MIX; r = - .28, p < .001, 95% CI [- .37, -. 20]], and unattractive friends [r = - .19, p < .001, 95% CI [- .28, - .10]]. This shows that attractive target faces gain less from being in the company of friends than unattractive individuals, thereby supporting the hierarchical account's key prediction.

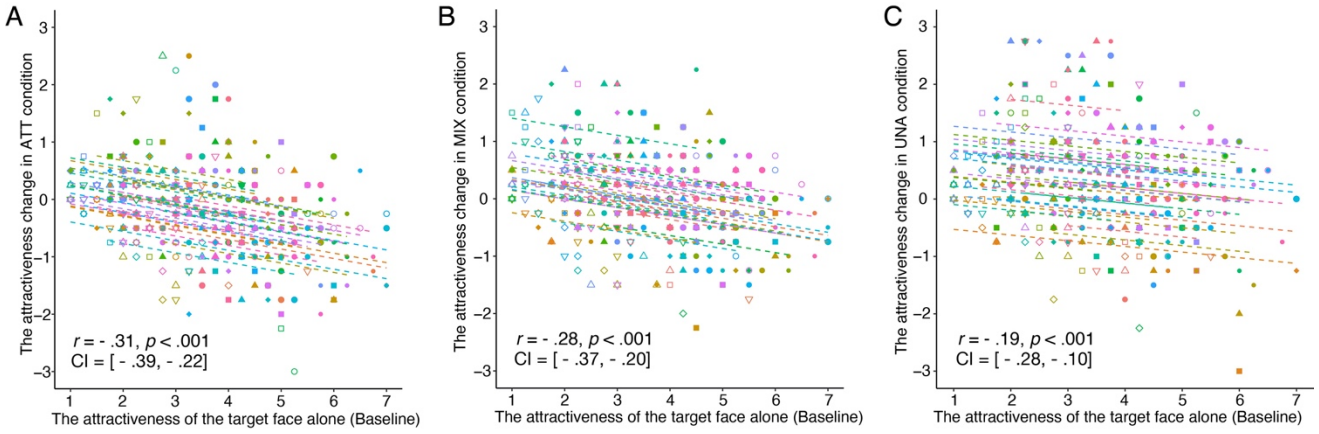

Figure 3. The repeated measures correlation plots illustrating the relationships between the friend effects (y-axes) and the attractiveness of the target in isolation (x-axes) in the (A) attractive, (B) mixed, and (C) unattractive friends conditions. These negative relationships, where the attractive targets benefit the least from being in a crowd relative to unattractive targets, provide support for the hierarchical account. Each unique color represents a single participant's data points and their trendlines (dashed lines). Each unique shape represents a single target facial identity.

One may wonder if the aforementioned significant correlations were caused by a lack of change in the attractive target face's ratings across all conditions. For example, a ceiling effect may occur where the most attractive target is not rated more attractive in any condition as an attractive target that is rated a 7 on a 7-point scale will not be able to gain any boost in attractiveness. Conversely though, if the attractive faces do not shift in attractiveness at all in company, then it may reflect a broader artifact of cheerleader effects only being apparent for unattractive faces. If this is the case, then there should be no difference between the ratings for the most attractive target face when viewed in an attractive or unattractive group.

First, we need to point out that the most attractive target was not rated a 7 in the baseline condition ($M_{\text{in isolation}}$ = 4.91). This suggests that there was plenty of scope on a 7-point scale for this face to be rated more, or less, attractive when viewed in the different groups of friends. To confirm this fact, we performed a *t*-test comparing the ratings for this target in the attractive (ATT) versus the unattractive (UNA) conditions. As expected, the most attractive face was rated differently across these groups [M_{att} = 4.49, M_{una} =5.10, $t(33) = 3.46$, p =.002, Cohen's d = .59]. A similar analysis also found the most attractive face was viewed as less attractive in the

attractive group relative to baseline [$t(33) = 3.34$, $p = .002$, Cohen's $d = .57$]. We anticipated this effect as the group of surrounding attractive faces were rated as more attractive in pretesting than the most attractive target used here, hence inducing a contrast effect; i.e., making this target appear less attractive when viewed with friends who were more attractive. By contrast, while there was a trend for the most attractive target to be rated as more attractive in the unattractive condition relative to baseline, this was not significant [$M_{una} = 5.10$, $M_{in\ isolation} = 4.91$, $t(33) = 1.10$, $p = .28$, Cohen's $d = .19$]. As this effect is quite small, but still in the predicted direction, it is possible that a larger sample size may yield a significant result.

To test the presence of a cheerleader effect for a highly attractive face in another way, we returned to the data from Experiment 1A. Figure 2A indicates the most attractive face appeared to gain more attractive responses in the unattractive relative to baseline condition, however, a *t*-test showed this effect was only a trend [$M_{att} = .98$, $M_{in\ isolation} = .95$; $t(33) = 1.92$, $p = .063$, Cohen's $d = .33$]. The fact that this trend was in the same direction as in Experiment 1B though suggests to us attractive faces will likely exhibit cheerleader effects. Moreover, we believe that our correlations in Figure 4 were not simply an artifact of the most attractive face failing to be altered in attractiveness in different conditions, as we do find the most attractive face shifting in the attractive group in the expected direction (i.e., negatively).

Experiment 2

Introduction and Methods

It is as yet unknown if cheerleader effects exist for trait judgments outside of attractiveness (Walker & Vul, 2014) and trustworthiness (Carragher et al., 2021). One trait that is likely to be altered in a group context is that of facial averageness. This is because prior work has shown that very average looking faces (e.g., those that do not stand out easily in a crowd; Rhodes & Tremewan, 1996, or that have few remarkable deviations in their structure; Langlois et al., 1994) are more attractive than those that are distinctive (e.g., those that do would stand out easily from a crowd). If the friend effects we observed in Experiments 1A and 1B were arising from alterations in facial averageness, then we should expect to find an averageness cheerleader effect, where faces become more average looking in unattractive groups. This would provide some support for the hypothesis that friend effects occur due to a target being averaged towards a

group's attractiveness.

Of course, it may be the case that when the target is biased towards the group's attractiveness, it happens to also become more average too as a consequence by the fact that attractive faces can to some extent appear average (Langlois, Roggman, & Musselman, 1994). Similarly, target attractiveness and averageness could be independently shaped by the presence of other faces, but it just so happens that both are induced in similar directions. It should therefore be stressed that we do not claim a causal role of one over the other here, but merely propose the possible ways in which the averageness cheerleader effect may be related to the attractiveness effect. The most important aspect of Experiment 2 will be to simply show the averageness cheerleader effect exists varying as a function of the attractiveness cheerleader effect.

To test the averageness cheerleader effect, we invited all participants from our first study (i.e., Experiments 1A and 1B) to participate in Experiment 2 (24 of them responded; 10 males, mean age of 19.7 years). This study was identical to Experiment 1A, but this time we asked participants to rate the target face as 'average' or 'distinctive', rather than 'attractive' or 'unattractive'. We decided to conduct the new experiment based upon the methods from Experiment 1A, as psychometric functions are typically more sensitive in detecting subtle perceptual changes than direct rating tasks (e.g., Ying et al., 2019).

Results Experiment 2

As expected, we found a positive relationship between the averageness effect and the attractiveness cheerleader effects [Figure 4, r = .41, p = .003, 95% CI [.14, .62]]; as the friend effect in Experiment 1A increased, so too did the averageness effect in Experiment 2. This meant that when target faces appeared more attractive in Experiment 1A (e.g., in the unattractive friends condition), they also happened to appear more average in Experiment 2. By contrast, being in the company of attractive friends led to target faces appearing less attractive in Experiment 1A, and more distinctive in Experiment 2.

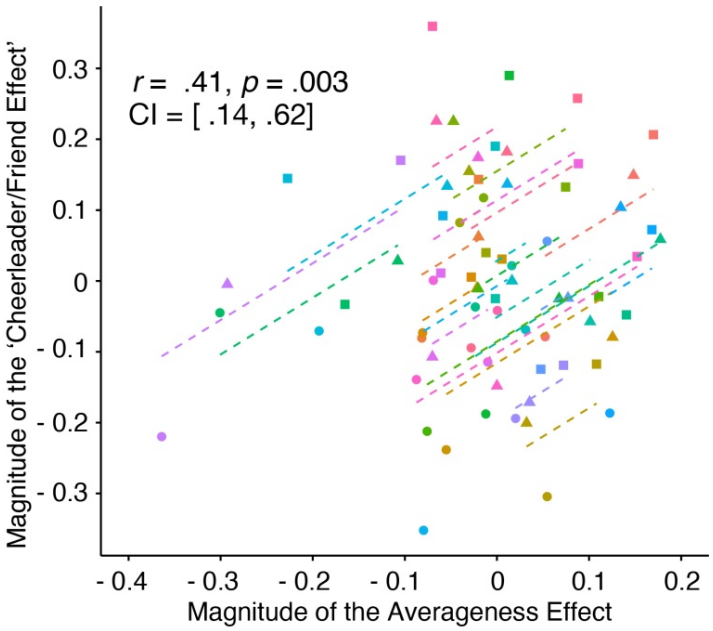

Figure 4. Repeated measures correlation plot illustrating the relationship between the PSEs of the averageness task and the PSEs of the attractiveness tasks. Each unique color represents a single participant's data for the unattractive (circles), mixed (triangles), attractive (squares) group conditions and their trendlines (dashed lines). Overall there is a positive relationship between the averageness and friend effects induced in the groups: target faces appear less attractive and more distinctive when surrounded by increasingly attractive friends.

Discussion: The Friend Effects Framework

Faces have been widely shown to be more attractive when viewed with friends than alone in isolation (Carragher et al., 2019; Furl, 2016; Walker & Vul, 2014; Ying et al., 2019). We hypothesized that if these cheerleader effects arose partly due to a contrast between the target face and its friends, then highly attractive friends may abolish or even reverse it. We confirmed this suggestion across the first two experiments (1A and 1B), showing that the presence of highly attractive and unattractive friends together, did indeed abolish the cheerleader effect. Moreover, when only highly attractive friends were present, we showed a reverse cheerleader effect, where target faces became less attractive than when viewed in isolation. Our results confirm that global friend effects exist, and that they can be a positive (e.g., the cheerleader effect) and negative (e.g., the reverse cheerleader effect) influence on our attractiveness. We also showed that the target face's attractiveness also contributes towards these friend effects, with unattractive

individuals benefiting more than their attractive counterparts, thus supporting the hierarchical account.

These findings confirm the dual influences upon friend effects (Figure 5): a contrast effect where increasing group attractiveness diminishes the positivity friends bring to your attractiveness, and a potential hierarchical effect, where increasing levels of your own attractiveness diminish the positive benefits of friends. In our third experiment, we found the first evidence that attractiveness cheerleader effects are also associated with alterations in averageness. To summarize these findings, we introduce a formal framework that illustrates the stimulus properties that induce friend effects, and the different phenomena in the literature that are related (The Friend Effects Framework: Figure 5).

Target Attractiveness Influences Friend Effects

Walker and Vul (2014) hypothesized that the cheerleader effect may arise due to the target face being processed with its friends' faces in an ensemble fashion that averages the target towards the mean of the group. As averageness is an attractive quality, this will result in the target appearing more attractive when viewed in the group than in isolation, with unattractive

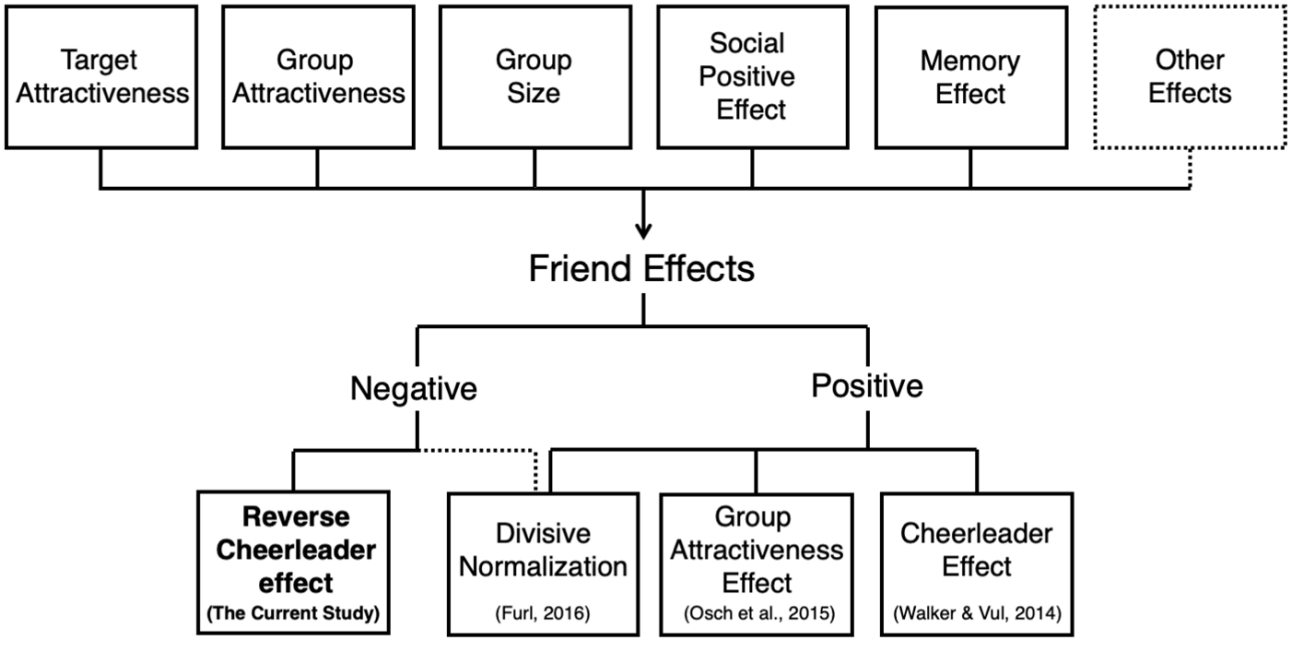

Figure 5. The Friend Effects Framework. At the top of the panel, we can see friend effects are driven by the target's attractiveness (increasing target attractiveness pushes friend effects towards negative), the group's attractiveness (increasing group attractiveness drives friends effects towards negative), group size (e.g., number of surrounding

'friends'), the social positive effect (e.g., as supported by identical target and friend images) and a memory effect (i.e., when faces are rated outside of view). Other effects (e.g., objects' influences on facial attractiveness, e.g., Carragher et al., 2019; Dunn & Searle, 2010) need further clarification that they are distinct from the confirmed target and group effects; hence the dotted line. Friend effects can therefore be viewed as an umbrella term that encompasses both the positive (i.e., make you appear more attractive: group attractiveness effect, cheerleader effect) and negative (i.e., make you appear less attractive: a reverse cheerleader effect) ways in which friends can shape your attractiveness. We indicate that divisive normalization is a positive effect as participants are more likely to choose one of a pair of faces as attractive over its paired counterpart when a third unattractive face is present. While this effect is positive in one sense (i.e., the superior face is more consistently selected as the most attractive when an additional 'friend' is present in a scene), it may also diminish the less attractive face's attractiveness too, although this has never been explicitly tested; the dotted line therefore represents this ambiguity.

targets benefiting more than attractive targets. We called this hypothesis the hierarchical account.

The negative relationship between the target's attractiveness in isolation and its friend effect (Figure 3) seems to bear this prediction out. Faces that were rated least attractive alone appeared to gain the greatest boost in attractiveness when surrounded by friends. By contrast, the presence of friends seemed to have a negligible, or even negative, effect on the most attractive faces, where they were viewed as less attractive in the group than in isolation. We hypothesize that unattractive targets may benefit being viewed in a group as the target is biased towards the average, whereas attractive faces largely do not. This is because while averageness is associated with attractiveness, attractive faces can possess qualities that make them more attractive than faces that are just average; i.e., highly average faces are not as attractive as faces that are simply highly attractive (DeBruine, Jones, Unger, Little & Feinberg, 2007). This means that attractive features contained in attractive faces may be lost when they are biased towards the ensemble's mean, thus diminishing their attractiveness. This hypothesis accords with the results in Figure 4.

This reverse cheerleader effect is quite remarkable as it contrasts with the bulk of the literature that shows being in the company of friends will invariably boost your attractiveness (e.g., Carragher et al., 2019; van Osch et al., 2015; Walker & Vul, 2014; Ying et al., 2019). Moreover, Experiment 2 suggested that cheerleader effects may arise from the surrounding group altering the target face's averageness. For example, highly attractive friends made the target face appear less average and less attractive relative to baseline. By contrast, the unattractive friends made the target seem more average and attractive. Similar contrast effects between targets and context have been shown in other work (Ying et al., 2019, 2020; Perrett et al., 1994; DeBruine et al., 2007).

The Presence of Others Induces Friend Effects

In addition to the surrounding faces' and the target's attractiveness contributing towards friend effects, Carragher et al. (2019) found that identical faces in a scene also elicit cheerleader effects. This seems to hint at a third mechanism through which friend effects can arise. We called this the social positive effect (Figure 5; Ying et al., 2019), where the mere presence of others may enhance our attractiveness in some way. However, this effect could potentially be explained through our group contrast and hierarchical accounts.

For example, imagine viewing a target face that is surrounded by many identical copies of itself (see Experiment 4, Ying et al., 2019; Carragher et al., 2019). When viewing the target, we are unable to extract the high spatial frequencies (i.e., fine grained details) of the surrounding faces that are presented in our visual periphery. Instead, when attempting to perceive these peripheral faces, we have to rely more on low spatial frequencies, i.e., extracting a blurry gist of the information that the faces provide (Burns et al., 2017; Rosenholtz, 2016). By contrast, faces in the fovea, such as when you are judging a target's attractiveness, rely upon both low spatial frequencies and high spatial frequencies. If averaging takes into account the weight of spatial frequencies in the scene, then the greater prevalence of low spatial frequencies in the friends may diminish the target's high spatial frequency information. This is because averaging the greater contribution of low spatial frequencies to the face norm created by those present in a scene would lower the spatial frequencies of the target overall. This would therefore reduce the fine-grained lines that may make a target appear older and/or unattractive; i.e., make blemishes and wrinkles appear fuzzier, and less defined, similar to the common media and advertising technique of airbrushing photographs to enhance beauty. However, this is merely speculation at this point, so future work will be required to test this hypothesis[1]. Regardless of how the social positive effect arises, it has been demonstrated and is thus included as an influence in our friend effects framework (Figure 5).

Memory and Ensemble Encoding Biases Partly Induce Cheerleader Effects

Most cheerleader effect studies require participants to rate the target's attractiveness once

[1] While Walker and Vul (2014) did show that blurring the target and surrounding faces in a scene still induces cheerleader effects, the extent to which blurring affected participants' perception between the fovea and periphery, and how these may interact, was not fully explored.

the faces are no longer visible onscreen (Walker & Vul, 2014; Ying et al., 2019). This means that these effects may largely occur due to a memory bias, where we remember a target in working memory as more attractive in the group than when viewed alone. According to the hierarchical account, this bias is induced because when the faces disappear from view, they remain held in working memory as a gist representation. As this average representation of a group of faces is more attractive than its constituent parts (Ying et al., 2020), and the faces stored in this gist are biased towards its more attractive mean (Brady & Alvarez, 2011), then this bias produces a cheerleader effect (i.e., the target is rated as more attractive in working memory). However, if working memory is not employed, then this bias will not occur, thus abolishing the cheerleader effect. Intriguingly, a recent paper appeared to confirm this hypothesis: when faces were rated out of view they elicited cheerleader effects, but when they were rated while still visible, the effect disappeared (Hsieh et al., 2020).

We agree Hsieh and colleagues' (2020) study provides compelling evidence that the cheerleader effect is partly driven by a memory bias, and we include this as a component in our model. However, we do not believe their results demonstrate the complete absence of a cheerleader effect when faces are rated in view. For example, we have shown here in our mixed conditions in Experiments 1A and 1B that cheerleader effects can be present at the level of the individual faces even when they are abolished at the group level, i.e., the unattractive faces gain more when viewed in a group relative to the attractive targets. If this alteration occurs at the perceptual level prior to the faces being held in working memory, then it would suggest that ensemble coding, otherwise known as ensemble statistics, is averaging each target towards the group's mean characteristics while the faces are in view, prior to a subsequent hierarchical effect. This latter component occurs in working memory once the faces are no longer visible, shifting the targets and friends as a group into appearing more attractive because they are represented as a gist, with their characteristics biased towards this gist. Further work will be required to test whether the averaging that occurs when faces are in view are identical to the type of averaging that occurs once they are out of view. This is important as it would show whether there is a distinction between the ways in which ensemble encoding and hierarchical representations are inducing friend effects.

Group Size Appears to Influence the Cheerleader Effect

A key prediction of the hierarchical account is that increasing group size should result in larger cheerleader effects. This is because as group size increases, then so too does the group's ensemble representation become more average. As averageness is an attractive quality (Langlois, Roggman, & Musselman, 1994), larger groups should result in larger cheerleader effects if the target takes on the group's average qualities. Prior work has typically failed to provide clear evidence that group size affects the cheerleader effect (Ojiro et al., 2015; Walker & Vul, 2013), however, both studies found similar non-significant trends for groups of nine faces inducing larger cheerleader effects than groups of four faces. This suggests to us that these experiments may have been too underpowered to detect significant effects. Confirming this hypothesis, a recent study testing a vastly larger sample of participants (n = 522) did demonstrate that cheerleader effects are indeed greater in larger groups (Peng et al., 2020). Increasing group size has also been shown to enhance the group attractiveness effect too (van Osch et al., 2015). We therefore believe it is reasonable to include group size as another factor that can influence friend effects.

What Role Does Target Attractiveness Play in Contrast?

The existence of what appears to be a hierarchical effect and contrast effect may appear paradoxical. For example, we found that faces viewed in highly attractive groups are perceived as less attractive than in unattractive groups. These shifts in perception seem to largely occur across all targets. However, if a contrast effect was occurring, then the most attractive targets should gain more than the least attractive targets when viewed in unattractive groups. This is because they are the best comparative option in the scene. In direct contrast to this prediction, we found unattractive targets are always benefitting more than attractive targets, irrespective of group attractiveness (Figure 3). If contrast requires the comparison between the target and the group, then why do the most attractive faces not benefit more in unattractive groups?

One explanation could be that our experiments were not designed to fully test the contrast hypothesis. Our groups were comprised of faces that were highly attractive and highly unattractive in order to demonstrate cheerleader effects could be abolished or even reversed. Relative to these sets, all of our targets may have simply seemed less, or more, attractive as a result of these extreme contrasts. If there was greater heterogeneity of attractiveness in the groups, then the target's own role in the contrast effect may start to become apparent. For

example, if faces of moderate attractiveness were used, then we are likely to see shifts consistent with the contrast hypothesis; i.e., attractive faces become more attractive, unattractive faces become less attractive (Lei et al., 2020). Future work testing cheerleader effects with groups of surrounding faces within the attractiveness range of the targets will help further reveal the target's own influence on the contrast effect.

In Experiment 1B there is a consistent relationship between the target's own attractiveness and the size of the cheerleader effect: less attractive targets always benefit more when viewed in a group compared to attractive targets. Similarly, if a reverse cheerleader effect is occurring, the less attractive targets receive a smaller negative impact than what occurs to the attractive targets. While these relationships appear consistent with the hierarchical account, future work will be needed to assess whether they are maintained when group attractiveness is varied in a less extreme fashion than we have employed here.

Also, we should remember that there is a component of the cheerleader effect that arises from the mere presence of faces, with an additive boost to this coming from some variance in the faces (Ying et al., 2019). As we see multiple influences on the cheerleader effect, it is possible there are multiple routes which allow for contrast and hierarchical assimilation effects to co-occur. For example, in our recent work we found two qualitatively different ways in which the brain can form the ensemble representations of faces based on attractiveness (Ying et al., 2020). Similarly, other researchers have observed simultaneous face-related effects of contrast and assimilation (Brooks, Sturman, & Gwinn, 2020). It is therefore possible that contrast and hierarchical effects may be driven concurrently by the same, or possibly different, facial properties.

Could a Single Contrast Process Fit All Our Data?

While we have proposed a target hierarchical effect and group contrast effect as shaping friend effects, one may wonder if a single dynamic contrast effect could explain the results we observe. In this account, the hierarchical hypothesis becomes redundant because friend effects arise purely through contrasts between the target and the group. While we are open to this possibility, we find the predictions made by a contrast mechanism difficult to reconcile with the friend effects that arise from the target's own attractiveness. For example, a contrast approach

would arguably suggest an attractive target should appear even more attractive in the company of unattractive friends, because this highly attractive target would become even more prized as the alternative options are very unattractive. When the same contrast is made between an unattractive target in a group of unattractive friends, the effect should be negligible, as all faces are still unattractive. Here though we see the opposite pattern emerge in our data: attractive targets benefit little when viewed in groups in comparison to unattractive targets who receive a larger benefit. This effect is apparent irrespective of group attractiveness, and is exactly the prediction made by the target hierarchical account.

A further issue with a single contrast account is that cheerleader effects are induced even when the group and targets are identical (Carragher et al., 2019). Our views on this are outlined in a prior section so we will just briefly state here that in a scene of identical faces, there is nothing for the target to be contrasted against. This, in our opinion, makes a purely contrast account insufficient. Instead, we and others have posited that this Social Positive Effect (Ying et al., 2019; or Social Inference Effect, Carragher et al., 2019) likely arises due to the presence of other faces indicating the target has positive qualities that may be inferred from its popularity. Alternatively, as we outlined earlier, this may be a perceptual phenomenon that arises from the brain averaging the groups' lower spatial frequency information from peripheral vision onto the target, making it appear more youthful, prototypical and having fewer blemishes and wrinkles.

Despite this, we do agree that contrast is likely to be a dynamic interaction between the target and the group. While we see robust contrast effects induced by the group's attractiveness here and in prior work (i.e., friend effects shift all targets similarly as a function of group attractiveness; Ying et al., 2019), and hierarchical effects (i.e., unattractive faces always gain more in any group in comparison to attractive targets), the presence of a target contrast effect (i.e., unattractive faces faring worse than attractive faces in attractive groups) is not so obvious here. As mentioned in the previous section, our study was not designed to fully test the role of the target's attractiveness in the contrast effect due to our employment of extremely attractive or unattractive friends. We believe future work will likely identify a dynamic contrast effect between the target and group exists, while also supporting the assimilative properties of hierarchical encoding occurring in tandem.

Explaining Prior Work that is Incongruent with the Target Hierarchical Account

There are some papers that have failed to provide support for the hierarchical account. For example, it has been suggested that if the hierarchical account is correct, then the size of the friend effects induced by the target and group should be related to a composite face that is created by morphing the target and friends together. This was attempted by Carragher and colleagues (2019), yet they found no link between the size of the cheerleader effect and the attractiveness of the composite face, with the authors suggesting this was evidence against the hierarchical account. However, this method does not take into account the group contrast effect we have observed here and in Ying et al. (2019). As groups increase in attractiveness, so too does the cheerleader effect diminish. This contrast effect could therefore have obscured any possible hierarchical effect of the target that may have been present in the cheerleader effect.

It has also been suggested that the hierarchical account can be rejected because cheerleader effects do not seem affected by presentation time (Carragher et al., 2020). This is due to the belief that increasing the viewing duration of faces in a scene diminishes the engagement of hierarchical encoding. This means that if hierarchical encoding was producing the cheerleader effect, then longer durations should result in smaller effects. While this may be the case, increased viewing time is also thought to result in larger face related contrast effects (Burton et al., 2016). It is therefore possible that extending the viewing duration during a cheerleader task simply resulted in larger group contrast effects that offset diminished hierarchical effects. Future work will be required to clarify such hypotheses.

Connecting the Diverse Friend Effects Phenomena

Typically, when participants are presented with two similarly attractive faces, they do not consistently rate one face as more attractive than the other. However, when an unattractive third face is introduced into the scene, participants start exhibiting a more consistent preference for one of the two attractive faces over the other. This consistency can be enhanced as the third face in the scene becomes increasingly more unattractive. This phenomenon is called Divisive Normalization (Furl, 2016) and we consider it to be a positive friend effect. This is because the most attractive face of the attractive pair is chosen as better looking than its counterpart when an unattractive face is placed in the scene. However, this effect may also occur by making the counterpart face appear less attractive, as yet, we do not know which hypothesis is correct as neither have been tested. Despite this, we believe a contrast effect could account for how divisive

768 normalization occurs.

769 For example, imagine two highly attractive faces, one a 9 and the other an 8.5. Participants
770 are not terribly consistent when judging one face as more attractive over the other (Furl, 2016). If
771 we add an unattractive face into the scene as occurs during divisive normalisation, then when we
772 look at the most attractive face in the pair (i.e., the 9), the surrounding group comprising of the
773 other attractive counterpart (i.e., the 8.5) and the unattractive distractor (i.e., the 2) yield a less
774 attractive group average ((8.5+2)/2 = 5.25) than when we look directly at the 8.5 (i.e., group
775 average (9+2)/2 = 5.5).[1] When viewing the 9, it is contrasted to the mean of 5.25, which
776 produces a difference of 3.75. When viewing the 8.5, the contrast between the group mean and
777 the 8.5 is much smaller at a 3 (i.e., 8.5 – 5.5). Thus contrast could explain why decreasing the
778 unattractive face's attractiveness leads to the more attractive face in the pair more readily
779 identifiable as the most attractive: the contrast effect is becoming stronger. This is because the
780 most attractive target is further away from the attractiveness of the group's mean. However, this
781 is speculative, and the presence of a hierarchical effect is currently unclear due to the forced
782 choice design used by Furl (2016). We anticipate future work utilising a ratings task, as we have
783 employed here in Experiment 1B, will be able to answer this, and connect the cheerleader effect
784 and divisive normalisation together.

785 The Group Attractiveness Effect (van Osch et al., 2015) is characterised by the fact that
786 groups are rated as more attractive than the mean of their individual members. As is the case
787 with cheerleader effects, prior work has shown this effect to be influenced by the group's
788 attractiveness, and the size of the group (van Osch et al., 2015). While van Osch and colleagues
789 (2015) failed to demonstrate target attractiveness as influencing the group attractiveness effect,
790 we believe that employing individual participant analyses, as we have done here, will possibly
791 demonstrate it is shaped by the target's attractiveness (i.e., the face a participant is viewing at
792 any given time) too.

793 *The Friends Effects Framework is not Limited to Attractiveness or Faces*

794 A growing body of work shows the presence of others alters a wide variety of trait

[1] Please note these group averages exclude the target that the participant is looking at. These data are hypothetical and only for demonstration purposes.

judgments for individual targets and groups. For example, friend effects are not limited solely to facial attractiveness, but are also present for judgements of facial averageness (Furl, 2016), trustworthiness (Carragher et al., 2021), and emotion (Goldenberg et al., 2021; Gray et al., 2017; Mihalache et al., 2021). Moreover, similar effects are apparent for bodies (Hsieh et al., 2020) and houses (Carragher et al., 2019). While our Friends Effects Framework accounts for face judgments in groups, we envisage it could easily be adapted into a broader Context Effects Framework to help understand the same effects for non-face stimuli. Currently missing from the literature though are direct tests of our framework using these traits and non-face stimuli. For example, can similar hierarchical effects be observed outside of attractiveness? Are these effects in the same direction as we observed here? These possibilities are currently unknown, but the lack of current knowledge provides researchers with a remarkably broad scope of potential topics to work on in order to help complete the picture.

Further Thoughts and Limitations

Many brain areas across the visual cortex have been linked to face perception (Chang & Tsao, 2017; Haxby, Hoffman & Gobbini, 2002; Kanwisher, McDermott & Chun, 1997), including attractiveness (Hahn & Perrett, 2014; Iaria et al., 2008; O'Doherty et al., 2003) and ensemble (Im et al., 2017) processing. Typically, it is argued that behavioural and neural responses to faces are dissociable from non-face stimuli (Kanwisher, McDermott & Chun, 1997); however, there is an ever expanding literature that suggests that this is not the case (Behrmann & Plaut, 2013; Burns, Arnold & Bukach, 2019; Burns & Wilcockson, 2019; Gauthier et al., 1999, 2000). In agreement with potential overlap between face and non-face processing, one study has shown cheerleader effects can be induced in a target face when it is surrounded by houses (Carragher et al., 2019). This is remarkably similar to other work that shows attractiveness levels in faces can be enhanced by the presence of apartment interiors (Dunn & Hill, 2014) and cars (Dunn & Searle, 2010). We therefore include this potential object related interactive influence (the 'Other Effects') within our friend effects framework in Figure 5.

Moreover, cheerleader effects can also be observed for non-face stimuli too, suggesting that these are not a face-specific phenomenon (Carragher et al., 2019). As averaging can occur for non-face stimuli (Halberstadt & Rhodes, 2003), our hierarchical and contrast accounts could

potentially be utilized to explain why objects also elicit these effects too[1] . Future neuroimaging and neuropsychological work will be required to confirm where these effects are occurring in order to connect our behavioural framework with a neural model.

Of course, we should note some limitations of our study: we only tested female faces, which is also true of most other cheerleader studies (Carragher et al., 2018, 2019; Ying et al., 2019). Some degree of caution should therefore be taken before assuming these exact effects will also be apparent for males. While Walker and Vul (2014) showed a cheerleader effect for male faces, one recent paper failed to replicate this finding (McDowell & Starratt, 2019).

There are though many potential reasons for this latter null result. For example, almost half of their participant sample was non-Caucasian, and it is not clear what race of faces used were. Some unforeseen other race effects, which are characterized by us performing better with faces of our own race than others (Bate et al., 2019; Burns et al., 2019, Estudillo et al., 2019; Meissner & Brigham, 2001), may therefore have abolished their cheerleader effects. Also, the participants rated the faces in classrooms with other students present (3-18 individuals per class, with sizes varying across participants), so presumably participants could see their classmates' faces when completing the experiment, again unduly influencing the results by abolishing the memory component (Hsieh et al., 2020). Finally, we have seen here that the presence of highly attractive friends can also abolish friend effects. Thus, there are many potential reasons that could have caused the lack of effects for male faces. Future lab based work that controls for these issues will be required to assess the presence of friend effects for male faces. Also, despite us having demonstrated our observed effects here across multiple studies, we did use the same participants throughout. While we believe our large effect sizes are indicative of true effects that are not unique to our present sample of participants, particularly as they match predictions from prior work in other cultures (Walker & Vul, 2014), it will be good to see these effects confirmed through replications in the future.

[1] We have been careful to make a distinction between the social positive effect (i.e., induced by the presence of other faces) and potential object effects. This is because we are uncertain if the face and object related effects are arising through common perceptual pathways (i.e., a group of friends or objects induce alterations in perceived averageness of target faces) or through a social inference mechanism (e.g., these friends and houses make this person seem more attractive due to social inferences that can be made about their status; Carragher et al., 2019). While we agree both are likely contributing to friend effects, we envisage for the time being that our framework's primary focus will be on the perceptual and memorial effects we can currently observe here and in other work. By contrast, we view social inference effects as likely being part of a broader framework of context effects.

Conclusions

There has been extensive research into cheerleader effects over the last few years (e.g., Carragher et al., 2018, 2019; McDowell & Starratt, 2019; Ojiro et al., 2015; Walker & Vul, 2014; Ying et al., 2019). Despite this, no study had been able to clearly demonstrate whether the target's attractiveness was influencing the cheerleader effect in a way consistent with hierarchical encoding. We have managed to show that this is likely the case, as increasing attractiveness in the target face diminishes the cheerleader effect. This is potentially because unattractive faces are averaged into the group, which makes them appear more attractive. By contrast, this averaging provides little benefit to attractive faces which are already attractive. We called this the hierarchical account in order to make it clear to readers that it is driven by the target's own attractiveness. We hope that this will help distinguish it from the second component of friend effects: the contrast effect. This phenomenon is characterized by increasing attractiveness in the surrounding friends driving down any benefit that being in a group may bring. This effect can be so strong that it results in the reverse cheerleader effect we observed in Experiments 1 and 2. Therefore, increasing group and target attractiveness both negatively impact upon friend effects. Friend effects can therefore have many influences (e.g., the target's attractiveness and the group's attractiveness), and can be negative (a reverse cheerleader effect) and positive (e.g., cheerleader effect, group attractiveness effect). Understanding these effects can help us connect a broad range of phenomena that occurs when we are seen with others. We anticipate that our new framework, with the identification of novel effects and influences, will help benefit future researchers who are interested in testing how friends and scenes influence our visual perception.

Authors' Credit Roles

E. Burns: Conceptualization, Visualization, Writing – Original Draft, Review & Editing. **W. Yang**: Conceptualization, Investigation, Writing – Review & Suggestion. **H. Ying:** Conceptualization, Methodology, Visualization, Data Curation, Funding Acquisition, Resources, Writing – Original Draft, Review & Editing.

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