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ORIGINAL PAPER

Self-concordant goal motivation influences how people respond to crowds, but not how they perceive them

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Abstract

There is an emerging debate around the idea that goals can shape perceptual experiences, guiding people to act in a goal-directed manner. The degree to which a person's motivation for goal striving is derived from internal versus external sources and aligns with their values, beliefs, and self-concept (i.e., self-concordance) plays an important role in determining successful goal pursuit but has been an overlooked factor in the research surrounding goal-driven perceptual phenomena. In the present experiment $n=66$ participants determined whether stimuli depicting crowds of moving people contained 10 or more individuals. We assigned participants to either a threat-goal condition, emphasizing the potential for threat in large crowds, or a control condition which had no additional justification for the task. We measured goal self-concordance for the task and manipulated both the size of the crowd and the proportion of individuals in the crowd performing threatening actions across trials. Self-concordance predicted less accurate responding, with participants over-estimating small crowds and under-estimating large crowds. Additionally, participants with self-concordant motivation in the threat-goal condition had faster reaction times and were less influenced by task instructions. Our findings suggest that the self-concordance of motivation for a task may influence the way participants respond to stimuli, rather than the way they perceive them.

Keywords Motivated perception · Goal self-concordance · Self-determination theory · Biological motion

Our perceptual systems enable us to interact with the world, and thus build the foundation that allows us to pursue goals (Parker et al., 2020), which can range from executing simple actions (e.g., reaching to grasp an object) to engaging in complex behaviors (e.g., processing verbal and non-verbal cues in a social exchange). Researchers have traditionally considered goal regulation – the management of behavior during goal pursuit– as dependent on "high-level" processes, such as response inhibition or planning, which occur in frontal regions of the brain (Eddington, 2014; Lopez et al., 2016; Solway & Botvinick, 2012). This framework assumes that the role of perception is to provide a stable, accurate representation of a person's world that permits, but does not actively enhance, goal pursuit. Diverging from this view, a new school of thought has emerged suggesting that successful goal striving can be understood by examining the interface between how people think about their goals and how they perceive their environment (Balcetis & Dunning, 2006; Leong et al., 2019; Cole & Balcetis, 2021).

This goal-driven account of perception proposes that actively pursuing a goal can influence the way the brain processes incoming sensory stimuli (Cole & Balcetis, 2021). For example, a thirsty person might see a glass of water as physically closer and consequently be more likely to reach for it, thus bringing their behavior into alignment with their goal (Balcetis & Dunning, 2006). The idea that perception can be shaped by "top-down" signals challenges the notion that perception provides an impartial source of information about the surrounding world. Instead, goals may actively mold perceptual process by enhancing sensitivity to goal-relevant elements of the environment or supressing

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All data for this project has been made publicly accessible via the Open Science Framework (https://osf.io/v3r54/).

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disruptive elements, ultimately increasing the likelihood that people will act in a goal-directed manner (Cole et al., 2021). There is a growing body of both behavioural (Cole et al., 2013, 2016; Stel & Van Koningsbruggen, 2015) and neurological (de Lange et al., 2018; Leong et al., 2019) evidence supporting the existence of goal-driven effects on visual (Balcetis & Dunning, 2006), auditory (Mayor Poupis, 2018), haptic (Arslanova et al., 2022), and olfactory (Shanahan et al., 2021) perception. Further, the combination of brain imaging with computational modelling has provided compelling evidence that goals can indeed influence early-stage sensory processes (Leong et al., 2019, 2021; Voss & Schwieren, 2015).

Goal self-concordance and the importance of motivational quality

Existing work on goal-driven perception has focused predominantly on the *quantity* (i.e., amount; presence/absence) of motivation, often using external motivators such as financial rewards. For example, to study the effects of motivation in visual categorization tasks Leong and colleagues (2019, 2021) produced ambiguious stimuli by presenting superimposed image categories and used monetary incentives to motivate the perception of one category over another. They designed their experiments such that participants stood to maximize their earnings by ignoring incentives, but nevertheless observed a preference for perceiving the rewarded category. Voss and Schwieren (2015) demonstrated similar findings using monetary reward and loss contingencies (i.e., conditions in which participants could make gains or avoid losses) to differentially motivate the perception of different colors from ambivalent stimuli. In a further example that demonstrates the effects of external motivation quantity on perception in other sensory modalities, Shanahan et al. (2021) tested participants' ability to discriminate food from non-food scents when they had either fasted or satiated themselves on the target food. The authors found that participants were more likely to perceive food scents when motivation to consume food was high (i.e., when they were hungry).

The approach of examining (external) motivation quantity overlooks an extensive body of psychological research, which has emphasized the importance motivational *quality* in goal striving (Ryan & Deci, 2017). Under Self-Determination Theory (SDT; Deci & Ryan, 1985; Ryan & Deci, 2017) motivation can be broadly categorized as either autonomous or controlled. Autonomous motives reflect intrinsic drives that align with a person's values, beliefs, or sense of enjoyment. Conversely, controlled motives imply behavior driven by extrinsic pressures or demands. Building on SDT, Sheldon and Elliot's Self Concordance Model (SCM; Sheldon & Elliot, 1999) suggests that people who have stronger autonomous than controlled motives for pursuing a goal experience a closer person-goal fit, as the goal aligns with the persons deep-seated inclinations and propensities (Sheldon et al., 2023; Sheldon, 2014). Such "self-concordant" goals typically produce more effective goal-directed behavior (for a review see Sezer et al., 2024). Some authors have suggested that people with self-concordant goal motivation are more effective because they rely to a greater extent on automatic, habitual, or unconscious strategies during goal striving (Milyavskaya et al., 2021; Milyavskaya & Werner, 2018; Werner et al., 2016). Goal-driven effects on perception, which are present even at early stages of sensory processing and occur outside of our awareness (Leong et al., 2019), represent a promising candidate as one such preconscious mechanism (Travis et al., 2019). Indeed, there is some evidence that self-concordant motivation can influence how people report experiencing their world (Leduc-Cummings et al., 2022). However, the methodology used in this research does not permit conclusions about whether these experiences are the result of fundamental changes to perceptual processing or the product of non-perceptual biases, such as how the individual responds to or interprets their visual environment (Firestone & Scholl, 2016).

Biological motion as a prototypical example of goal-relevant stimuli

The brain is sensitive to statistical regularities (Friston, 2010), and it is thus plausible that stimuli more commonly involved in goal striving may be more conducive to eliciting goal-driven perceptual effects. Biological motion refers to the movements of other people in the environment (Johansson, 1973). Perceiving biological motion plays a central role in our interactions with others and is thus highly relevant for any goal that requires interpersonal interaction (Han et al., 2022; Kuzmanovic et al., 2013). Further, the need for social connectedness is a fundamental building block for self-concordant motivation (Ryan & Deci, 2017) and goals requiring the accurate interpretation of biological stimuli may thus be more likely to be self-concordant. Evidence indicates goals can influence visual processing of biological stimuli (Alt & Phillips, 2022; Kuzmanovic et al., 2013). This is particularly true of goals involving social interaction, in which individuals must perceive and interpret the actions of others in line with their own aims. For example, participants tend to perceive ambiguious biological motion, in which depth and configural cues have been removed masking the true facing/walking direction of a person, as facing towards them (Vanrie et al., 2004), an effect that is heightened when walkers have a higher potential for affecting social interaction by being either closer/faster (higher likelihood of initiating interaction), or being larger (higher likelihood of exerting influence over social interactions) (Han et al., 2021). Additionally, individuals with stronger social anxiety symptoms are more likely perceive such ambiguious biological motion stimuli as approaching (Heenan & Troje, 2015; Yiltiz & Chen, 2018), which has been attributed to their stronger motivation to detect and avoid social threats in the environment (Han et al., 2021) and a reduced ability to inhibit threatening percepts (Heenan & Troje, 2015). Crowds can enhance the processing of information from biological motion and may be similarly influenced by motivation (Alt & Phillips, 2022). For example, the perceived threateningness of a crowd may be heightened when individuals are prejudiced to sense threats (Cooley et al., 2020). Motion is key in such situations (e.g., is a person raising a fist or waving a hand?) but there is little knowledge about goal-driven influences on the processing of biological motion. As a common, prototypical example of a goal-relevant visual stimulus, we suggest people with self-concordant motivation for goals associated with detecting threats should be more perceptually sensitive to threat cues in the environment.

Aims and hypotheses

We designed an experiment to examine the role of self-concordant goal motivation in biological motion perception. Briefly, we presented participants with stimuli depicting crowds of moving people and asked them to assess whether the crowd contained more or less than 10 individuals, while manipulating the size of the crowd across trials. Additionally, we manipulated the proportion of individuals in the crowd performing threatening versus non-threatening actions. To assess the specificity of goal-driven perceptual effects, we told one group that the reason for the task was because large crowds can pose a threat (threat-goal condition), while the other group were not given a specific reason for the task (control condition). We evaluated whether the different task instruction produced differences in behavioral responses and reaction times for individuals with lower or higher self-concordant motivation to examine whether observed effects can be attributed to changes in perceptual processing or non-perceptual cognitive biases.

Our hypotheses pertain to goal-driven effects on patterns of responding. If the goal-driven perception account holds, we would expect that having a self-concordant motivation for the task should boost the sensitivity and efficiency of processing goal-relevant information. We hypothesized that goal-self concordance will affect both discrimination performance (H1) and reaction times (H2). Specifically, we predicted that:

H1a: Higher goal self-concordance will predict more accurate crowd size discrimination.

H1b: Participants in the threat-goal condition will be more accurate at discriminating crowd size than those in the control condition when there is a high proportion of threatening individuals.

H2a: Higher goal self-concordance will predict faster reaction times.

H2b: Participants in the threat-goal condition will respond faster to crowds that contain a high proportion of threatening individuals compared to participants in the control condition.

Methods

Transparency and openness

This study and hypotheses were preregistered on the Open Science Framework (OSF; https://doi.org/10.17605/OSF.IO/YE2K4). We have made all data, as well as code for reproducing the stimuli and data analysis available on the project's OSF page (https://osf.io/v3r54/). In our registration we planned to conduct computational modelling to examine whether observed effects could be attributed to the rate of perceptual evidence accumulation in the brain; however the reaction time distributions of several participants was not unimodal and right-skewed. We therefore considered these distributions not appropriate for drift diffusion modelling and model parameters might yield inappropriate or misleading results (Ratcliff & McKoon, 2008). We have provided the analysis code for the drift diffusion modelling on the project's OSF page but do not report this analysis as part of the present study.

Sample size justification

The concept of statistical power for multilevel models involving several fixed and random effects is complex, particularly in the absence of prior research to guide judgements regarding 'reliable' estimates of population effects. Pragmatics and conservative expectations for effect sizes based on Monte Carlo simulations of drift diffusion (Lerche et al., 2017) and multilevel models (Arend & Schäfer, 2019) guided a priori decisions regarding sample size targets. We estimated 66 participants each completing a minimum of 400 trials (200 per condition) would provide > 80% power to detect moderate sized between-group effects. We presented 230 trials per condition (460 trials in total) to improve precision of our estimates and account for potential attentional lapses, missing data due to technical or other unforeseen issues.

Participants

We recruited a convenience sample of 66 undergraduate students from an Australian university campus as participants for this study. Most participants were female (*n* = 44 female, *n* = 21 male, *n* = 1 non-binary) and white (*n* = 34 white, *n* = 21 Indian/Asian, *n* = 4 black/African/Caribbean, *n* = 7 other ethnicity listed/prefer not to say). All participants had completed at least a high school level of education. The mean age of the sample was 19.91 years (*SD* = 2.57). All participants self-reported as having normal or corrected to normal (i.e., with glasses/contacts) vision. Participants received course credit for taking part in the study. Testing of these participants was approved by the Curtin University Human Research Ethics Committee.

Procedure

Upon arriving at the lab participants were randomized into either the threat-goal condition (*n* = 35) or a control condition (*n* = 31) by a random number generator. Both researchers and participants were blind to conditional assignment. We gave participants in the threat-goal condition the following task description:

> Threat detection is an important human function. Large crowds can pose a threat to the safety of individuals. In the current task, you will view stimuli depicting crowds of moving people. The goal of this task is to identify threatening situations by determining whether the crowd has 10 or more people.

And told participants in the control condition:

> Judging numerosity is an important human function. The size of crowds can be challenging to determine when people move around. In the current task, you will view stimuli depicting crowds of moving people. The goal of this task is to identify whether the crowd has 10 or more people.

Importantly, the task in both conditions was fundamentally the same (i.e., to detect crowds of 10 or more people), but goal-relevant information differed, with participants in the threat goal condition were given information about the potentially threatening nature of large crowds. Although assigning goals to participants (i.e., rather than having them self-select goals) may undermine autonomy, it enabled us to explicitly test the effects of goal instructions on perception and behavior in a standardized way. Given critiques of motivated perception have pointed out that the lack of investigation of the effects of instructions represents a potential confound in previous work (Firestone & Scholl, 2016), we made the decision to maximize experimental control despite potential effects on participant autonomy in the current study. We then measured participant's self-concordant motivation for completing their respective goal (see *Goal Self-Concordance Measure*). Participants then completed the experimental task, in which they viewed on a computer monitor crowds of point-light biological motion stimuli (see *Biological Motion Stimuli*) developed using Matlab (The Math Works Inc, 2023a) and the Psychtoolbox version 3 (Brainard, 1997).

Across experimental trials we varied both the number of people in the crowd and the proportion of individuals in the crowd performing threatening actions. Crowds contained 6, 8, 10, 12, or 16 people. We reasoned that crowds containing just above or below the 10-person target should be the most difficult to discriminate accurately and should therefore yield the largest goal driven perceptual biases. Thus, we chose to focus the majority of trials on 8 and 12 person crowds to maximize data quality at these stimulus levels while minimizing task repetitiveness. We presented the 8 and 12 person crowds 200 times each, and the 6, 10, and 16 person crowds 20 times each. In half of the trials for each crowd size, 70% of people in the crowd performed threatening actions (threatening crowds), while in the other half of the trials 30% of people in the crowd performed threatening actions (non-threatening crowds). Crowd sizes and threat levels were randomized across the experiment.

We displayed each crowd for 1,000 milliseconds (ms). After this time the crowd disappeared and the screen remained blank. Participants could respond at any time from the stimulus onset. Participants indicated that crowds contained ≥ 10 or < 10 people by pressing the "a" or "l" keys on keyboard respectively. We instructed participants to keep their left and right index fingers resting on these keys for the duration of the experiment so they could respond as quickly as possible. Prior to commencing the experiment, we gave participants 10 practice trials to familiarize themselves with the task. Practice trials mirrored the experimental task with the key difference being that the first practice trial always contained exactly 10 people. We informed participants of this and told them the first practice trial was intended to provide a benchmark to judge the following crowds against. For the remaining practice trials, the crowd size was randomly generated. We monitored participants during practice to ensure that they were responding to the stimuli with the correct button presses and understood the task. In total the experiment took approximately 30 min to complete.

Goal self-concordance measure

We measured the degree to which motivation for the task goal was self-concordant using the Comprehensive Relative Autonomy Index (Sheldon et al., 2017). This validated instrument asks participants to rate (1 *not at all* – 7 *very much so*) their agreement with 24 items describing different types of motivation that range from non-concordant (negative introjected, external) to self-concordant (internalized, identified, positive introjected). The scale also includes amotivation items. Amotivation describes the absence of motivation rather than a reason for doing the task (Deci & Ryan, 2000) and is thus conceptually distinct from both autonomous and controlled motivation. Where autonomous and controlled motivation both energize and direct behaviour, amotivation refers to the lack of intention or reason to act (Deci & Ryan, 2008). Given the incongruence between amotivation and goal-oriented behaviour, we opted to exclude this subscale. We adapted the stem to make it appropriate for each participant's assigned instruction condition. For the control condition participants responded to the stem: "I will try to achieve the goal of determining whether crowds exceeds 10 people because:" and in the experimental condition participants responded to the stem "I will try to achieve the goal of identifying threatening situations by determining whether crowds exceeds 10 people because:". We computed an index of relative goal self-concordance for each participant by subtracting the average score for non-concordant motivation items from the average score for self-concordant motivation items. Given our exclusion of the amotivation subscale, which would typically be combined with negative introjected and external motives, we opted to use the approach of averaging rather than summing subscales (i.e., Sheldon et al., 2017) to avoid over-weighting autonomous motives in the RAI calculation. More positive scores indicate greater self-concordance of the goal. Internal reliability of the scale in the current study was high ($\alpha = 0.895$). Means and standard deviations for subscales are presented in supplementary material.

Biological motion stimuli

Point-light biological motion was generated by placing markers on the major joints of an actor's body as they perform an action while removing spatial information from the limbs and body (Johansson, 1973). Point-light biological motion is advantageous because it lacks spatial cues, such as a person's race or appearance, which could influence task performance (Firestone & Scholl, 2016), but remains recognizable as a human performing an action (Beintema & Lappe, 2002; Troje & Westhoff, 2006), even when presented in crowds (Riddell & Lappe, 2018; Sweeny et al., 2013). We obtained biological motion stimuli of dyads performing neutral (e.g., walking, shaking hands) or aggressive (e.g., pulling, hitting) actions from the Carnegie Mellon University Graphics Lab Motion Capture Database (www.mocaps.cs.cmu.edu).

Analytic strategy

Mixed effects modelling of response data and reaction times

Multiple trials nested within participants cannot be considered independent, justifying a multilevel approach to analysis. First, we used a two-level generalized linear mixed effects model with a binomial link function to assess how fixed effects of crowd size, self-concordant motivation (grand mean centred), crowd threat level, and threat goal condition predicted the likelihood of producing a response indicating the crowd contained ≥ 10 people. Second, we used a two-level linear mixed effects model to assess the effects of crowd size, self-concordant motivation (grand mean centred), crowd threat level, and threat goal condition on reaction times. We transformed reaction times using an inverse transform (1/RT) to reduce skewness of reaction time distributions. We conducted this analysis in R (R Core Team, 2023) using the lme4 package (Bates et al., 2015). We used simple slopes analysis to decompose significant interactions involving continuous variables in these models. Specifically in the presence of a significant interaction with a continuous variable, we compared modelled slopes at one standard deviation above the sample mean to modelled slopes one standard deviation below the sample mean (Liu et al., 2017).

Results

Prior to analysis we screened the data for outliers and removed trials with responses < 100ms or > 5000ms from stimulus onset. We reasoned that extremely fast responses likely represent errors given that biological motion processing requires a minimum of 100ms (Krakowski et al., 2011) and extremely slow responses likely represent attentional lapses given the stimulus was only visible for 1000ms. We removed one participant whose pattern of responding indicated they had misunderstood the task instructions and had used the wrong keys to indicate responses (i.e., their response curve was inverted). We present means, standard deviations, and between-participant and within-participant bivariate correlations for the study variables in Table 1.

Table 1 Means, standard deviations, and bivariate correlations between study variables at the within-person and between-Person levels

		Between-Person Correlations			Within-Person Correlations	
	Mean (SD)	Self-Concordance	Threat Goal Condition	Reaction Time	Crowd Threat	Crowd Size
3. Self-Concordance	1.06 (1.06)	-	−0.097	−0.042	-	-
4. Reaction Time	1529.88 (493.69)	−0.042	0.010	-	−0.002	**0.019**

Note: bolded values indicate p-values < 0.05

Table 2 Effects of goal Self-Concordance, crowd threat, crowd size, and goal Condition on the likelihood of participants indicating a crowd contains ≥ 10 individuals

	Estimate	SE	*P*-value
Fixed Effects			
Intercept	-6.910	0.187	< 0.001
Goal Self-Concordance	0.331	0.146	0.024
Crowd Size	1.353	0.031	< 0.001
Threat	−0.116	0.225	0.608
Goal Condition	−0.403	0.257	0.116
Goal Self-Concordance × Crowd Size	−0.072	0.025	0.003
Goal Self-Concordance × Threat	0.162	0.177	0.359
Crowd Size × Threat	0.020	0.044	0.650
Goal Self-Concordance × Goal Condition	0.421	0.273	0.123
Crowd Size × Goal Condition	0.076	0.043	0.077
Threat × Goal Condition	0.339	0.308	0.271
Goal Self-Concordance × Crowd Size × Threat	−0.027	0.035	0.429
Goal Self-Concordance × Crowd Size × Goal Condition	−0.062	0.046	0.176
Goal Self-Concordance × Threat × Goal Condition	−0.237	0.331	0.475
Crowd Size × Threat × Goal Condition	−0.080	0.060	0.179
Goal Self-Concordance × Crowd Size × Threat × Goal Condition	0.049	0.064	0.445
Random Effects			
σ (Participant)	0.258		

Response data

We first investigated how experimental variables predicted the likelihood of producing a binary response indicating the crowd contained more or less than 10 walkers. We present parameter estimates for this model in Table 2. There were significant fixed effects of crowd size and goal self-concordance; moreover, crowd size interacted with goal self-concordance to predict the likelihood of generating a response indicating a crowd contained more than 10 walkers. As can be seen in Fig. 1, participants with high self-concordant motivation were more likely to overestimate the size of small crowds (i.e., more likely to erroneously indicate a crowd had more than 10 members) and underestimate the size of large crowds (i.e., less likely to correctly indicate a crowd had more than 10 members). This trend was confirmed by a simple slopes analysis showing a difference in slopes ($b = 0.217$, $SE = 0.034$, $p < .001$) between individuals one standard deviation above the average level of self-concordance compared to those one standard deviation below this average level. Contrary to our hypotheses, there were no main or interactive effects of the proportion of threatening walkers in the crowd.

Reaction times

Our second model investigated how experimental variables predicted reaction times to stimuli. We present parameter estimates for this model in Table 3. There were significant two-way interactions between crowd size × self-concordance and crowd size × goal condition, as well as a significant three-way interaction (depicted in Fig. 2) between crowd size, threat goal condition, and relative autonomy. A simple slopes analysis of the three-way interaction revealed that reaction time slopes differed between the conditions at lower than average ($b = 2.77\text{e}^{-5}$, $SE = 5.91\text{e}^{-6}$, $p < .001$), but not above average ($b = 5.38\text{e}^{-6}$, $SE = 6.27\text{e}^{-6}$, $p = .391$) levels of goal self-concordance. Specifically, when self-concordance was above average, the association between reaction times and crowd size did not differ between the two groups, regardless of instruction condition; however, for below average self-concordance individuals, reaction times increased with crowd size when they were given a goal that emphasised the threateningness of the stimuli and decreased with crowd size when this information was not presented (Fig. 2). Similar to the results we obtained for response data, there were no effects of crowd threateningness on reaction times.

Exploratory analyses

Using a laboratory-based task with researcher-imposed goals may have undermined participant autonomy and represents a key limitation of the current study. We further examined participant motives by plotting the distribution of C-RAI scores, as well as scores for the autonomous motivation, and controlled motivation subscales (see Fig. 3). Participants tended to rate autonomous motives higher than controlled motives and controlled motives scores in particular were skewed towards the lower end of the scale. Although

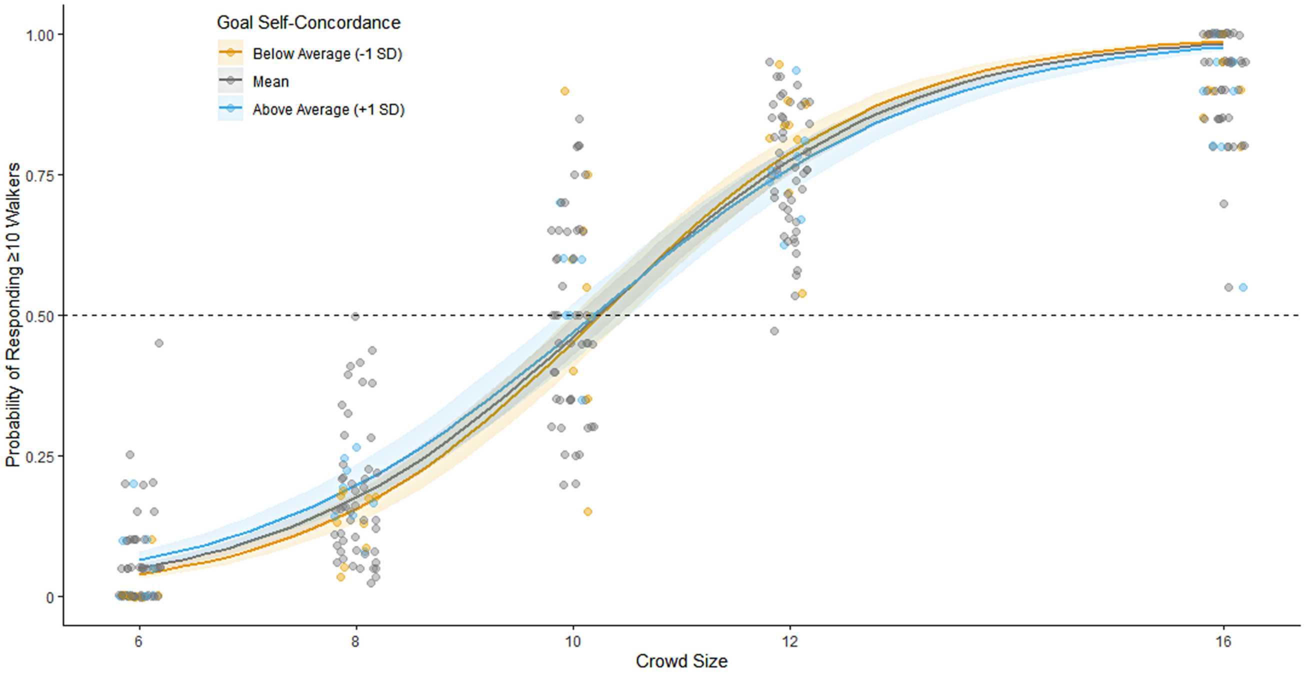

Fig. 1 Model Estimated Probability of Indicating a Crowd Contains ≥ 10 Individuals Dependent on Goal Self-Concordance. Points Show Actual Participant Data. Shaded Area Represents 95% Confidence Bounds

it appears that participant autonomy was not undermined by our study design, it should be noted that overall scores on the 7-point scale were only moderate ($M_{autonomous}$ = 3.418, SD = 1.298; $M_{controlled}$ = 2.360, SD = 1.272). To assess whether autonomous and controlled motives differentially predicted performance on the task, we re-ran our analyses using the individual motives scores as predictors rather than the aggregate C-RAI score. We used general linear mixed models to assess both response data and reaction times given the non-normal distribution of the individual motives scales as they are robust to violations of normality in predictor variables. We present results of this analysis in Table 4. The most notable difference to our primary analysis was the emergence of a three-way interaction between goal motives (both autonomous and controlled), crowd size, and goal instruction condition, which predicted the likelihood of producing a response indicating the crowd contained 10 or more individuals. Mirroring our primary analysis, individuals with higher than average autonomous motivation were again found to be less accurate, tending to make fewer responses indicating the crowd contained 10 or more walkers at larger crowd sizes when given instructions that the goal of the task was to detect large threatening crowds. This pattern of results was also found when examining the influence of controlled motives. These interactions are presented graphically in supplementary material.

Discussion

The purpose of the present study was to investigate how the quality of motivation for goal striving affects the processing of goal-relevant information, specifically biological motion. We tested the proposal that self-concordant goals (Sheldon & Elliot, 1999) are associated with changes to early sensory processing. We found that both, self-concordance of goal motivation and providing differing goal instructions influences patterns of responding and response times; however, the pattern of results was not in line with what we would expect if these differences were produced by changes in sensory mechanisms. Reaction times for individuals with more self-concordant motivation were faster and less influenced by goal instructions, but responding was less accurate. Despite these unexpected results, our study provides several interesting insights into how goal instructions and motivation quality influence performance on perceptual tasks. Although we did not find clear evidence that goals exert a top-down influence on perception (Cole & Balcetis, 2021), we do show that they can bias the way people respond.

SDT and the SCM are prominent theories in modern social psychology and there is an extensive body of work showing that self-concordant motivation predicts more effective goal striving in a variety of contexts (e.g., Ng et al., 2012; Ryan et al., 2022; Vasconcellos et al., 2020). Recent meta-analytic structural equation modelling has shown that self-concordant motivation predicts behaviors and

Table 3 Effects of goal Self-Concordance, crowd threat, crowd size, and goal Condition on Inverse Transformed Reaction Times (1/RT)

	Estimate	SE	*P*-value
Fixed Effects			
Intercept	8.634E-04	6.263E-05	< 0.001
Goal Self-Concordance	5.919E+00	4.965E-05	2.378E-01
Crowd Size	8.472E-06	4.283E-06	4.790E-02
Threat	1.692E-05	3.139E-05	5.899E-01
Goal Condition	4.000E-05	8.582E-05	6.428E-01
Goal Self-Concordance × Crowd Size	-1.163E-05	3.393E-06	6.000E-04
Goal Self-Concordance × Threat	-4.409E-05	2.486E-05	7.620E-02
Crowd Size × Threat	-2.015E-06	6.057E-06	7.394E-01
Goal Self-Concordance × Goal Condition	-5.466E-05	8.940E-05	5.432E-01
Crowd Size × Goal Condition	-1.732E-05	5.833E-06	3.000E-03
Threat × Goal Condition	-1.195E-05	4.275E-05	7.799E-01
Goal Self-Concordance × Crowd Size × Threat	8.012E-06	4.798E-06	9.490E-02
Goal Self-Concordance × Crowd Size × Goal Condition	1.741E-05	6.103E-06	4.300E-03
Goal Self-Concordance × Threat × Goal Condition	6.710E-05	4.474E-05	1.337E-01
Crowd Size × Threat × Goal Condition	1.582E-06	8.248E-06	8.479E-01
Goal Self-Concordance × Crowd Size × Threat × Goal Condition	-1.337E-05	8.631E-06	1.214E-01
Random Effects			
σ (Participant)	3.919E-05		

cognitions that are adaptive for goal striving, which are, in turn, related to goal progress (Gaudreau et al., 2012; Sezer et al., 2024). Despite the influence of SDT and the SCM in the motivation literature, the idea of goal self-concordance has been largely overlooked when it comes to motivational influences on perception. A key contribution of this work is the integration of goal-driven perception with these established theoretical frameworks. Contrasting with our prediction that more self-concordant motivation would improve perceptual performance (H1a), we found individuals with stronger self-concordant motivation produced less accurate patterns of responding by overestimating small crowd sizes and underestimating large crowd sizes. Critically, we did not observe any effect of our crowd threateningness manipulation (H2b), suggesting that the observed pattern of responding was not dependent on goal-relevant properties of the stimuli and thus is unlikely to arise due to changes in perceptual mechanisms. We suggest that rather than changing the way visual information is processed, differing qualities of motivation may have instead influenced the way people responded to the experimental task.

A common, yet often ignored, criticism of goal-driven perceptual phenomena is that effects attributed to changes perceptual mechanisms may actually be due to biases in the way participants respond to stimuli (Firestone & Scholl, 2016). Our study explicitly addressed this possibility by using goal instructions that either emphasized or de-emphasized a particular attribute of the stimuli presented to participants, namely the threateningness of crowds. If goals influence the way people perceive goal-relevant information in the environment (Cole & Balcetis, 2021), we would expect to see differences between these conditions emerge as the amount of goal-relevant information in the stimulus is varied. The finding that effects of motivation occurred independently of threat cues in the stimuli indicates that rather than changing the way participants *see* crowds, motivation appears to have biased the way they *respond* in the task, irrespective of perceptual information, which inadvertently resulted in poorer task performance. Interestingly, much of the research that has demonstrated strong evidence of effects of motivation on perception has relied on highly artificial and perceptually ambiguious stimuli (e.g., superimposed images (Leong et al., 2019, 2021); biological motion with depth and configural cues removed (Han et al., 2021). It may be the case that top-down motivational information only influences perception when bottom-up perceptual signals are highly unreliable (Friston et al., 2010). When perceptual signals provide a relatively credible reproduction of the physical environment the role of motivation may instead be to instigate actions, which change the environment, in the hope that new incoming sensory information about this changed environment will better align with their desired state of the world (Mansell, 2021).

Supporting this conclusion, exploratory analyses showed that when people had stronger autonomous or controlled goal motives, their patterns of responding were more susceptible to counterproductive biases induced by task instructions. This suggests that a stronger drive to do a task can lead people to adjust their behaviour to align with what they think they should be doing, rather than what their sensory systems are telling them. Interestingly, both quality and quantity of motivation appear to play a role in producing counterintuitive behaviour. It may be the case that either a strongly internalized desire to do well or a strong drive to achieve one's goal (regardless of whether motivation originates internally or externally) can effectively lead people to behave contrary to their sensory input. As an example, imagine two individuals reviewing a building site for hazards, one is the architect who is heavily invested in seeing their dream come to fruition, the other is an inspector who is under pressure from their boss to get the approval through. Both might unintentionally fail to recognize or respond to perceived hazards, but might do so for different reasons.

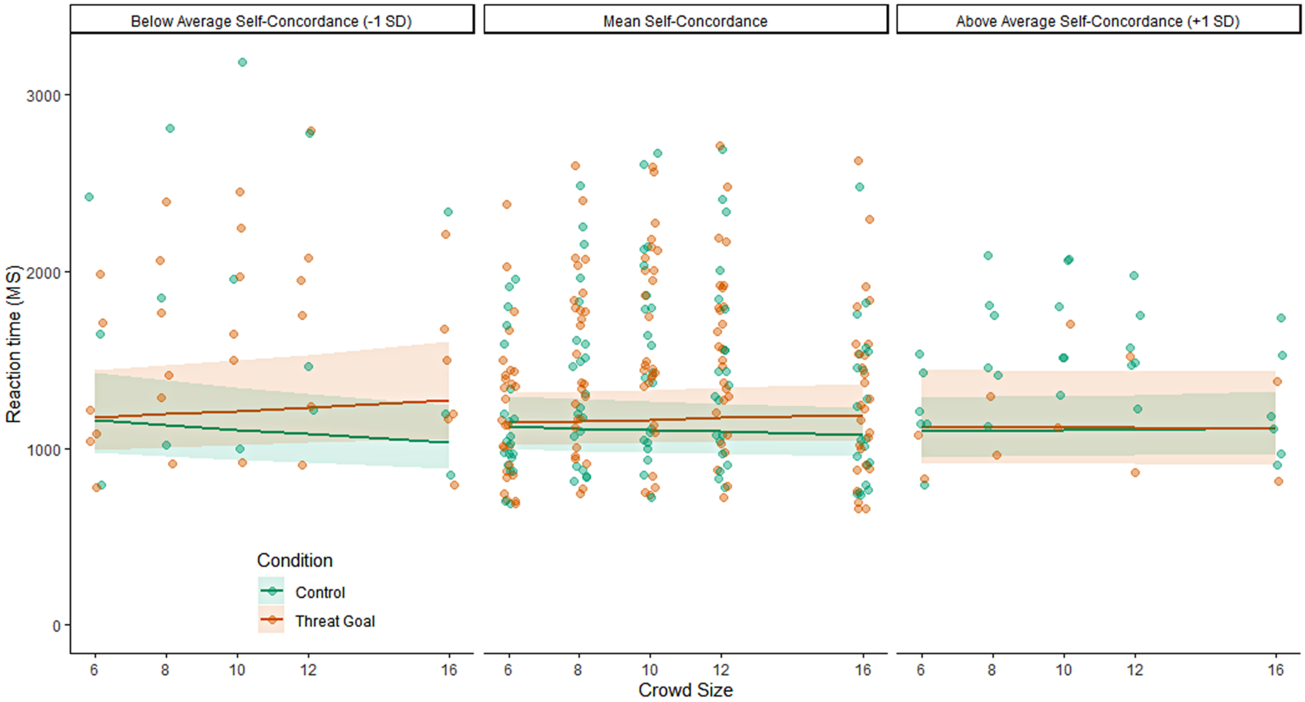

Fig. 2 Modelled Interaction Between Goal Self-Concordance, Crowd Size, and Goal Condition Predicting Reaction Times. Points Represent Actual Participant Data. Shaded Area Represents 95% Confidence Bounds

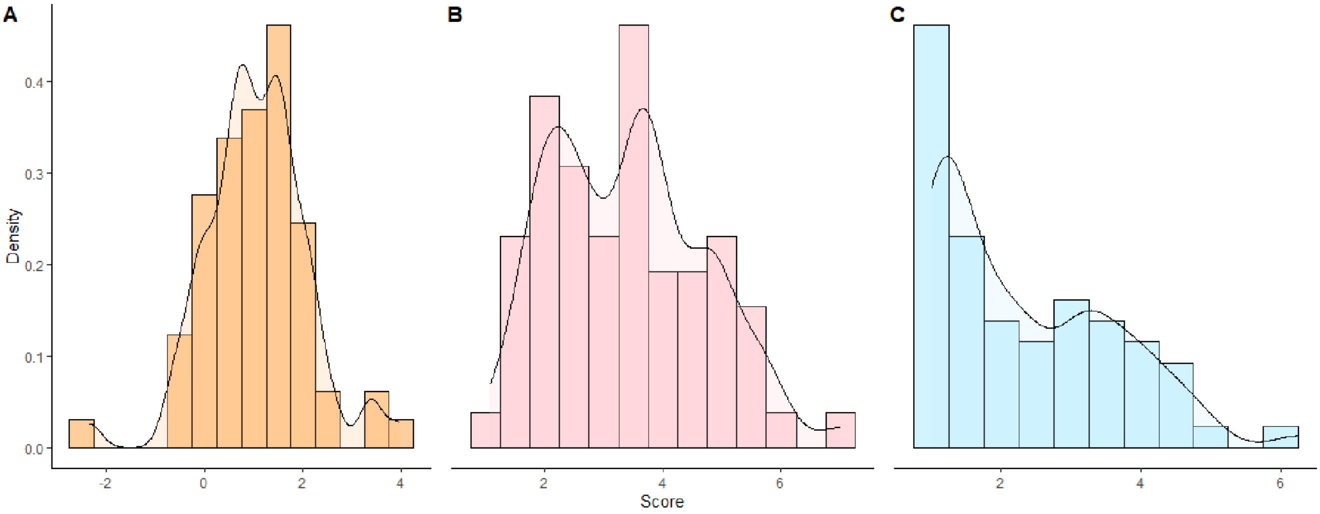

Fig. 3 Distribution of Participant Scores for (**A**) Relative Autonomy Index, (**B**) Autonomous Motives, and (**C**) Controlled Motives

Our data would suggest that the architect, who is more internally motivated, may actually be more likely behave contrary to what their sensory systems are telling them than the inspector; however, we recognize the need to test whether our results generalize outside of laboratory settings with researcher-set goals.

Our argument is also supported by our analysis of reaction times. Reaction times of individuals with above average self-concordance were faster and were not moderated by task instructions. Conversely, participants with moderate or below average self-concordance adjusted the speed of their responding based on task instructions, with goal instructions that emphasize threateningness of crowds resulting slower responses at larger crowd sizes, though again this was irrespective of actual threat cues in the stimuli. These results supported our hypothesis that higher goal self-concordance should be related to faster reaction times (H2a); but not the hypothesis that participants in the threat-goal condition would respond faster to crowds that contain a high proportion of threatening individuals (H2b). Again,

Table 4 Effects of Autonomous and controlled goal motives, crowd threat, crowd size, and goal Condition on the likelihood of participants indicating a crowd contains ≥ 10 individuals and Inverse Transformed Reaction Times (1/RT)

	Responses						Reaction times					
	Autonomous Motives			Controlled Motives			Autonomous Motives			Controlled Motives		
	Estimate	SE	P-value	Estimate	SE	P-value	Estimate	SE	P-value	Estimate	SE	P-value
Fixed Effects												
Intercept	-6.721	0.186	< 0.001	-6.803	0.182	< 0.001	8.82E-04	6.28E-05	< 0.001	8.84E-04	6.12E-05	< 0.001
Crowd Size	1.314	0.031	< 0.001	1.330	0.030	< 0.001	7.77E-06	4.36E-06	0.075	5.39E-06	4.23E-06	0.203
Goal Condition	− 0.612	0.255	0.016	− 0.613	0.251	0.015	4.32E-05	8.51E-05	0.614	2.72E-05	8.34E-05	0.745
Threat	− 0.115	0.224	0.608	− 0.063	0.219	0.773	9.98E-06	3.20E-05	0.755	4.02E-06	3.10E-05	0.897
Motivation	− 0.326	0.146	0.025	− 0.593	0.138	< 0.001	-1.70E-05	4.83E-05	0.726	-6.43E-05	4.50E-05	0.157
Crowd Size × Goal Condition	0.115	0.043	0.007	0.116	0.042	0.006	-1.95E-05	5.87E-06	0.001	-1.61E-05	5.73E-06	0.005
Crowd Size × Threat	0.022	0.043	0.620	0.011	0.042	0.799	-1.13E-06	6.17E-06	0.855	2.19E-07	5.98E-06	0.971
Goal Condition × Threat	0.339	0.306	0.268	0.300	0.304	0.323	-8.65E-06	4.31E-05	0.841	-3.79E-06	4.20E-05	0.928
Crowd Size × Motivation	0.065	0.024	0.008	0.124	0.024	< 0.001	-5.66E-06	3.35E-06	0.092	4.90E-06	3.11E-06	0.115
Goal Condition × Motivation	0.767	0.201	0.000	0.770	0.201	0.000	9.98E-05	6.57E-05	0.133	1.57E-04	6.56E-05	0.019
Threat × Motivation	0.179	0.177	0.310	0.019	0.168	0.910	-8.59E-06	2.46E-05	0.727	2.96E-05	2.28E-05	0.193
Crowd Size × Condition × Threat	− 0.082	0.059	0.163	− 0.075	0.059	0.201	1.85E-06	8.31E-06	0.823	5.68E-07	8.10E-06	0.944
Crowd Size × Condition × Motivation	− 0.167	0.034	< 0.001	− 0.184	0.034	< 0.001	-1.12E-06	4.56E-06	0.806	-1.51E-05	4.54E-06	0.001
Crowd Size × Threat × Motivation	− 0.037	0.034	0.277	− 0.010	0.033	0.762	2.71E-06	4.74E-06	0.567	-4.40E-06	4.40E-06	0.317
Condition × Threat × Motivation	− 0.278	0.243	0.252	− 0.107	0.244	0.660	1.05E-05	3.34E-05	0.753	-3.73E-05	3.32E-05	0.262
Crowd Size × Condition × Threat × Motivation	0.061	0.047	0.190	0.030	0.047	0.525	-2.00E-06	6.45E-06	0.756	7.50E-06	6.41E-06	0.242
Random Effects												
σ (Participant)	0.505			0.500			3.10E-04			3.12E-04		

as reaction times were not influenced by attributes of the stimulus, but rather attributes of the instructions, we are led to conclude that this is the result of decisional, rather than perceptual processes. We suggest a simple explanation for both the reaction time and response data observed in the current experiment is that individuals with above average self-concordance placed increased emphasis on responding quickly, which came at the expense of accuracy (i.e., speed accuracy trade-off; Heitz, 2014).

The finding that effects of the instruction manipulation on reaction times were only apparent when self-concordance was below the average of the sample suggests that external and internal loci of motivation may bias behavior in different ways. The finding that individuals with less self-concordant motivation responded faster to stimuli when given more detailed goal instructions emphasizing threats suggests that decreased performance in individuals with controlled motivation may be a result of attempting to cope with an undesirable/threatening task by getting through it quickly. This aligns with evidence that individuals with controlled motivation are more likely to appraise their goal as threatening and use coping strategies associated with escape or avoidance (Ntoumanis et al., 2009). Conversely, individuals with more self-concordant motives are more likely to appraise goals as challenges and use approach-based coping strategies (Riddell et al., 2022). Rather than trying to do the task quickly, these individuals may be spending more cognitive effort trying to do the task "correctly" but not necessarily quickly. Other authors have questioned whether goal-driven effects observed in perceptual experiments could potentially be due to the way researchers present information to participants or inadvertent demand characteristics in task instructions (Firestone & Scholl, 2016). We provide evidence that this can indeed be the case, and moreover that motivational characteristics may interact with instructional cues to produce unique patterns of counter-perceptual behavior. There is an extensive body of literature on errors in perceptual judgements in both laboratory and applied settings (e.g., Mather, 2008). Often, errors that do not have a clear perceptual root are attributed to the presence of internal "noise"; however, these errors often exhibit systematic individual differences (Vilidaite & Baker, 2017; Stocker & Simoncelli, 2006), indicating that this noise is not entirely random. Based on the present work, the present findings suggest that one potential source of noise in perceptual judgements, particularly when systematic patterns emerge, may stem from motivational factors. Investigating how motivational mechanisms explain how and what type of perceptual judgements errors people make represents an exciting avenue for future research.

Interpersonal interaction is a fundamental characteristic of the human experience and lies at the core of many goals (e.g., making friends, avoiding unsafe situations; Alt & Phillips, 2022; Deci & Ryan, 2000). We reasoned that visual areas responsible for biological motion processing could plausibly have strong connections to higher level areas (e.g., Sokolov et al., 2018), making biological motion more susceptible to goal-driven influences on perception than more abstract stimuli or stimuli that are less commonly encountered during real-world goal striving. Despite the relevance of biological motion to day-to-day goal striving, we did not find conclusive evidence that the perception of biological motion stimuli is susceptible to motivational influences. This raises some question as to what, if any, stimuli are best suited to studying goal-driven effects. Some of the most compelling evidence for goal driven perceptual effects, where behavioral results are supported by computational modelling and neuroimaging (Leong et al., 2019), has come from using visually ambiguous stimuli. It may be the case that motivational influences on perception are most sizable when the brain is forced to resolve noisy or unclear information in the environment. Top-down signals may be less influential when the perceptual input is clear or easily interpretable. Although we did not observe goal-driven perceptual effects in the current study, we cannot rule out the existence of such effects entirely. Instead, we suggest that goal-driven perceptual effects may be reserved for situations when incoming sensory information is less reliable or even ambiguous. Importantly, our results emphasize the importance of considering study design and potential confounds when developing studies to investigate goal-driven perceptual phenomena.

Limitations and future directions

We recognize that a more extensive protocol would allow us to obtain a finer grained picture of how goals influence crowd perception, for example having a wider variety of crowd sizes and greater variation in the threateningness of crowds may have enabled us to better assess affects associated with threat perception. These extensions should be attempted in future work. Additionally, we intended to use drift diffusion modelling to provide stronger evidence that observed effects were due to cognitive or perceptual mechanisms, but were unable to fit these models to the current dataset. Nonetheless, we contend that this approach has much to offer and should be reattempted in the future. We suggest that future work in this space could attempt to manipulate motivation experimentally for example through priming (Brown et al., 2016) or the provision of autonomy supportive versus controlling environments (Healy et al., 2014; Sheldon et al., 2020) in order to provide stronger arguments for causal associations between motivation and observed effects. Relatedly, we note that the laboratory-based nature of our study and the researcher assigned goals we used may have undermined autonomy in the present study. Having a more ecologically valid setup with self-set, real-world goals would have produced higher autonomous motivation, but would have come at the cost of experimental control, which given previous criticism of work in this field (Firestone & Scholl, 2016), was a key consideration for the current study. Additionally, our results offer some intriguing possibilities about how self-concordant goal motivation, which is indicative of internalized value, might influence speed accuracy trade-offs. We suggest further investigation of this possibility would be a fruitful area for future research.

Conclusion

Over three decades of research have taught us that not all goals are equal. The quality, rather than quantity, of motivation for goal striving is often the key factor determining success (Vansteenkiste et al., 2009). By introducing the conceptual frameworks of the SCM and SDT, we situate the burgeoning field of goal-driven perception within well-established and extensively researched goal striving theories. Although the evidence we provide does not support the proposition that more self-concordant motivation produces stronger perceptual effects, it does suggest that self-concordance of motivation for completing a task can influence the way in which people respond in perceptual tasks. People who have better quality, more internalized motivation may try to complete tasks with substantively different behavioral strategies than those who complete the tasks for externalized reasons. This is a critical consideration for the study of goal-driven perception going forwards and more broadly for any study that looks to investigate the influence of both internal or external reward on perception. Researchers should be aware that quality more than quantity of motivation for a task may produce biases in responding, which if not accounted for could lead to the misinterpretation of results. Extensions of the present work may have potential ramifications more applied settings. Here, we provide initial evidence as to how motivational influences may lead people to make counterintuitive decisions that may appear to contradict perceptual evidence. Perhaps the key question this generates is whether such effects occur in real-world goal striving. History is littered with examples of individuals making illogical choices despite the evidence “right in front of their eyes”. Rather than failing to see the obvious choice, people who are highly motivated may instead overlook or underweight perceptual evidence in favor of a decision that would produce their desired outcome.

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