**Reviewer #1**

In this study, the authors sought to dissociate reward from attention. They used SSVEPs, superimposing two random dot kinematograms of different colors flickering at differing frequencies. In a trial-by-trial cueing paradigm, participants were asked to attend to one color and look for a phase of coherent motion within that color. They propose two different models as to how reward and attention may function (salience view vs. voluntary attention view). A baseline period was first recorded, followed by a training session in which the two different colors were associated with high and low probability of reward, respectively. After this, a test session was run where the same stimuli were used and no reward was given. They found that sensitivity was most improved for the low reward condition vs. high, but the response times were improved by reward for both low and high conditions, but more so for high. The SSVEPs revealed a main effect of attention, an increased SSVEP response to the high reward condition in training regardless of attention, which was then reduced in the test phase. The authors conclude that reward likely interacts with attention in a way which combines both of the proposed models.

I find the approach of testing these two models (salience view vs. voluntary attention view) quite appealing, and the authors do a good job of describing this in their introduction. I am not totally convinced, however, that a low reward stimulus would show no level of enhancement during the training session when it is attended. It is, of course, still rewarding. The authors should expand more on the direct evidence from the literature for this prediction.

Along the same lines, the empirical evidence for the voluntary attention view needs to be expanded. There is clear evidence (behavioral and ERP) for the salience view, but the empirical evidence for the voluntary attention view is lacking, and the authors even state in the discussion that there aren't explicit predictions as to how these models might modulate activity in visual cortex. Therefore, it isn't quite clear how the authors arrived at the schema of the models they present and more literature supporting this view should be provided so that is seems plausible.

An aspect that is a bit problematic here, is that with the models, it isn't clear what level of processing these are supposed to predict. That is, are the predictions limited to early visual areas, slightly later visual areas, or something even more general? This becomes important given the epoching of the data analysis. Because the analysis of the SSVEPs starts at 500 ms, it is not capturing any of the early effects, which could be highly informative. The authors allude to this in the discussion, but it is hard to draw conclusions from this as what may be being captured here is some sort of later sustained effect, and not immediate attentional capture, which could, of course, operate independently.

Were trials with and without responses collapsed for the SSVEP analysis? Although the signal analyzed is likely mostly visual, it could definitely be influenced by the presence of target movement. Moreover, in trials for which a false alarm occurred, or no target detection occurred, the participant's attention was likely elsewhere, and including such trials would only add noise to any effects.

One study which is not cited here is that of Buschschulte et al., 2014 (JoCN). In this study, there is a dissociation of reward and attention in visual cortex, as measured with MEG. The authors should include this study in their manuscript, and indicate what their findings add that goes beyond what was reported by Buschschulte.

The results from the detection sensitivity, in which the low reward seemed to show the most benefit are ignored and should be discussed.

Minor:

In the schematic of the predictions, although it is obviously done so for depiction purposes, I would put the starting points for the baseline condition for high and low reward at the same 'level.'

Please check the genders of the subjects reported as the numbers don't add up to the total number of participants.

The task structure/timing needs to be described a bit more. Did the dots onset and move already at the same time as the cue? Or was there a period between the cue and the onset of the dots? Was there any sort of jittered ITI?

One line in the methods says, "One-third of trials contained one, two, or three coherent motion intervals, occurring with equal probability in the attended and unattended color RDK." Then, it is stated "Out of those 100 trials, 40 trials contained no dot motion, while 60 trials contained one, two, or three dot motions (20 of each)." This doesn't seem to match up mathematically and needs clarification.

**Reviewer #2**

The current study provides evidence for an enhanced visual processing of rewarded stimulus features. Interestingly the design of the study allows for a differentiation of attentional processes and reward-related processes by assigning high and low reward values to one of two visual features only after attentional resources have been allocated the features. The results suggest that reward enhances processing independent of endogenous visual attention processes.

The work is interesting and certainly of interest to the readership of the journal. However, there are a couple of things the authors need to address.

The major issue regarding the current results concerns the design of the baseline phase and the recorded results during that stage of the trial:

In Line 104 the authors describe the logic of the baseline condition: "…after a baseline period used as control condition, these two colors were systematically associated with a low or high probability of earning a reward in a training phase." After looking closely at the methods section, I understood that for each subject one single color was assigned as high rewarded color throughout the experiment. One critical question would be whether this assignment was conducted at the beginning of the experiment or only once the training blocks started, since the reward association during the baseline phase would be identical to the test blocks in the first case. The behavioral results add confusion to the nature of the baseline phase since a substantial effect of reward probability is present for d' during the 4 baseline blocks. The reaction times do show the same effect of reward during the later baseline blocks as well. However, no effect should be visible if the reward association was not established yet. This issue becomes more problematic since the reward effect during baseline is quite substantial and at least during the later baseline phase similar in size compared to the main effect (high vs low) during the reward association phases. If this was the case, the generally improved performance after a rewarded color has been assigned would rather be attributed to a higher global cognitive engagement during the training phase.

The authors need to describe the baseline in more detail. Furthermore, they need to discuss the reward effect observed during this baseline phase of the experiment although no association has been established. Interestingly, the authors do in fact mention a similar premise (Line 308: "…reward probability cannot affect the baseline phase.") but fail to discuss its contradiction in the data.

I do believe that the same problem persists in the electrophysiological results. Although in Table 4 no amplitude differences between high and low reward during baseline can be seen, this lack of reward effect may well be an artefact caused by the correction method applied. All ssvep power amplitudes were normalized by the mean ssvep amplitudes across attention conditions during baseline, thus effects of reward (between frequencies 10 and 12Hz) would be marginalized within the same baseline conditions.

Different ssvep responses for different experimental phases as well as error regions cannot be distinguished in figure 4. If the authors point is to highlight that feature, an additional bar- or boxplot might be helpful.

**Reviewer #3**

This article reports a study investigating the effect of reward on processing of visual stimuli. Participants completed a global motion detection task, in which each display contained random dot kinetograms (RDKs) in two different colors, and participants were instructed to attend to one color (and report coherent motion for this color) and ignore the other. During a training phase, correct detection responses for one color produced high reward, and for the other color produced low reward. During a subsequent test phase, rewards were no longer available. Dependent variables were speed and accuracy of responding, and magnitude of SSVEPs elicited by the stimuli. Findings were somewhat complicated. The introduction of rewards sped up responses for the high reward color more than the low reward color, but also increased accuracy more for the low reward than the high reward color. SSVEPs increased more for the high-reward than low-reward color when rewards were introduced, but declined to similar levels again in the test phase. These effects were independent of the requirement to attend or ignore the color (though see point 3 below). These findings do not follow easily from a view in which reward enhances voluntary attention (because then the effect of reward should depend on whether the color should be attended or ignored), or from a view in which reward enhances stimulus salience (since then the effect of reward should persist into the test phase).

The question of how reward influences visual attention - whether this reflects a top-down or bottom-up process - is an interesting one. However, it is also a question that has been the focus of a great deal of previous research. When combined with the somewhat unclear results of the current study, the novel contribution made by this study is perhaps not what might be expected for an article published in NeuroImage. I discuss this and other issues below.

1. P5: "Importantly, the effects of reward history and voluntary attention are often difficult to dissociate, and they are commonly confounded in cognitive tasks". Contrary to this statement, it's not really that difficult to deconfound effects of reward history and voluntary attention - and indeed it's something that's been done in hundreds of published studies over the last 5-10 years that have looked at the effect of reward on attention capture. The current article cites some reviews of this body of work (Anderson, 2016; Awh et al., 2012; Chelazzi et al., 2013; Failing & Theeuwes, 2017). These studies clearly demonstrate an effect of reward on attention that does not depend on top-down, voluntary selection - that is, this existing work shows that reward can influence salience independently of goals. It is also clear from a moment's reflection that reward can "influence the processing of stimuli by increasing the amount of voluntary attention deployed toward these stimuli" (p5). If I'm told that I will be given $100 for detecting targets in location X, but nothing for detecting targets in location Y, then clearly I will pay more goal-directed attention to location X than location Y.

So we already know that reward can influence both automatic capture of attention (salience, in the language of the current article) and voluntary deployment of attention. This somewhat undermines the rationale for, and contribution of, the current study - which effectively tests these same ideas but in a slightly different way from previous research. And it's not clear what the advantage is of the current procedure over previous approaches: little justification is provided for why this study uses a global motion detection task, why each trial combines a low-reward and high-reward stimulus (as opposed to combining each separately with a neutral stimulus) etc.

2. P7 outlines predictions of the "voluntary attention" and "salience" views. It wasn't always clear to me why particular predictions were made. For example, it is stated that "The salience view also predicts the suppressed processing of the low reward stimuli", with Fig 1 showing a reduction in salience of low-reward stimuli (below baseline) when rewards are introduced. Why would suppression necessarily occur on this account? Low-reward stimuli are still paired with reward, it's just that this reward is not as large as that paired with high-reward stimuli. So arguably the low-reward stimuli should also increase in salience, just not as much as the high-reward stimuli. The salience account predicts that high-reward stimuli will have higher salience that low-reward stimuli, but it is not explicit about exactly how this will be realized (whether high increases and low decreases, or both increase, or both decrease). Likewise it's not clear why Fig 1 shows, for the voluntary attention view, that the unattended low reward stimulus decreases below baseline. If the stimulus is unattended, then on this account surely its reward-signaling status does not matter.

While on the topic of Fig 1, some of the patterns shown here don't really make sense. For example, panel A suggests that processing of attended, low reward stimuli will be higher during the baseline and test phases than for attended, high reward stimuli (values for the low reward stimuli are higher on their y-axis). Ditto for panel B. I note that the y-axes are not labeled, so perhaps the scale is meant to be different in the lower graphs. More generally though this figure seems overcomplicated: it might make more sense to plot changes in the high-versus-low reward \*difference\* across phases of the design, which really constitutes the crucial reward-related effect.

3. P23 notes that: "Crucially, this effect [influence of reward on SSVEPs] was the same both when the high reward stimulus was attended and unattended. Thus, this effect was independent of the effect of voluntary selective attention". But as shown in Table 3 and noted on p20, the model in which reward and voluntary attention interacted performed only slightly worse than the model in which these effects were independent. So it's not clear that the data provide especially strong and selective support for this "crucial" finding.

4. The terminology around the ideas of attention and suppression seems confused/confusing in places. For example, p7: "the voluntary attention view predicts that the processing of the high reward stimuli will be enhanced only when they are attended… the processing of [low reward] stimuli will be suppressed only when they are not attended". This passage seems to draw a distinction between "enhanced processing" and "attention", and likewise between "suppressed processing" and attention. This didn't make sense to me: I would see these terms as essentially synonymous. That is, saying that a cue is attended means the same as saying that its processing is enhanced; likewise suppression of processing of a cue means that that cue is less likely to be attended.

Similarly, p23 states "This pattern of results suggests that the effect of reward acted independently of visual selective attention". But if SSVEPs are really a measure of stimulus processing, then isn't the implication that reward is influencing visual selective attention? That is, the change in stimulus processing caused by reward changes the likelihood that stimuli will be processed/selected/prioritized. Should this sentence instead say something like "independently of voluntary attention"?

5. Some important methodological details are missing:

- We are told that the two RDKs flickered at 10 or 12 Hz, but there are many ways in which this could be realized. What were the on and off times for the stimuli?

- "One-third of trials contained one, two, or three coherent motion intervals" (p9). Why was this manipulation of number of motion intervals included? How long after stimulus onset did the motion intervals occur? We are told that responses were counted if they occurred between 200 and 1500 ms after coherent motion onset. Given that the RDKs occurred for only 3,250 ms, if there were three motion intervals on a particular trial, the implication is that response periods for the different intervals would overlap: how is it decided if the current response was a fast response to the most recent motion interval, or a slow response to the previous motion interval?

- How fast did the dots move during the motion intervals?

- We are told there were 4 practice blocks with 60 trials each. What happened during these practice blocks?

- "After each block, participants received feedback on their performance" (p8). What feedback did they receive? Mean speed and accuracy?

- Were participants explicitly informed before the test phase that rewards were no longer available? This seems crucial to the rationale of the experiment, but it's not stated anywhere.

- How were reaction times defined? i.e., when does timing start? At the onset of the most recent coherent motion period?

6. SSVEPs were calculated in a time-window from 500 ms to 3,250 ms after stimulus onset. As far as I can tell, this window will include not only the initial stimulus presentation, but also the 1-3 coherent motion periods, the participant's response, and feedback - and the feedback in turn depends on the phase of the procedure, the trial type, and the participant's response. Consequently I don't see how differences in SSVEPs can be confidently ascribed to differences in stimulus processing, when there are so many other factors varying between trials. Given that SSVEPs are a key dependent variable, this issue may undermine the conclusions drawn from this study.

7. Analyses of behavioral data concentrate on the reaction time findings (which show faster responses in the high reward condition), but largely ignore the finding that sensitivity showed a larger improvement for the low reward condition when rewards were introduced. Is there a reason for sidelining this finding? Does it suggest a speed-accuracy tradeoff, for example?

8. Figure 4 shows a strange pattern in SSVEP data: for the 10 Hz stimulus, mean amplitude is larger when the stimulus is attended than when it is unattended, but for the 12 Hz stimulus this pattern is reversed. This pattern is not commented on anywhere in the article as far as I can see - how should it be interpreted? In particular, the finding of greater SSVEP magnitude when the 12 Hz stimulus is unattended vs attended seems to undermine the interpretation of SSVEP magnitude as a measure of attention selection that is made in the rest of the article.

More specific points:

- P3: "This process depends on our current goals… and the physical salience of stimuli…. Recent research has indicated that motivation can influence selective attention by impacting both of these factors". Motivation (reward) cannot influence the \*physical\* salience of stimuli. The physical salience of a stimulus relates to the distinctiveness of its physical features (its brightness, color, loudness etc). These features do not change when a stimulus is paired with reward, and hence physical salience does not change. Reward associations might change the overall salience of a stimulus, but they do not change its physical salience specifically.

- "One person was excluded due to noisy EEG data" (p8). How was this decision made, i.e. what constitutes sufficiently noisy data that a participant should be excluded?

- P19: "Supplementary analyses carried out to assess possible training effects…". What is meant by "training effects" here? Changes over the course of each phase?

- P19: "There was a very small increase in the reaction times in the test compared to training phase for the high reward color (M = 4.07; 95% HDI [-4.52, 13.10]; ER = 4.40), and no difference for the low reward (M = 1.87; 95% HDI [-6.93, 10.70]; ER = 1.98)". What's the criterion here for labeling one of these effects "very small" and the other "no difference" (of course there is a difference; the question is whether it is a \*meaningful\* difference)?

- P21: "… thus resulting in infinite probability". Probability cannot be infinite, it is bounded between 0 and 1.