Am I There Yet?:
Probing the Effects of Goal Progress Feedback on Cognitive Motivation
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This thesis was submitted in partial fulfillment of the requirements for the Bachelor of Arts degree in Psychology from Princeton University.
This paper represents my own work in accordance with University regulations.

/s/ Felicia Ng
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Abstract

Goals are constant directors of human behavior, as people’s lives are regularly guided by the pursuit of quantifiable objectives, but a ubiquitous problem arises in the difficulty of sustaining the motivation necessary for achieving those goals. Although an abundance of self-tracking technologies have been designed to help address this issue, little systematic research has been conducted to identify the features that are most effective in motivating users. Established theories and recent data from social and consumer psychology research suggest that providing goal progress feedback with certain valences and visualization features significantly influences commitment and persistence across a broad range of domains including physical tasks and purchasing behaviors. The present research expands upon this literature by investigating the combined effects of goal progress feedback valence and visualization at different goal distances on motivation to expend cognitive effort towards a set goal. A controlled behavioral experiment was conducted using a 2 x 2 x 2 mixed factorial design with an additional control condition in an anagram game to evaluate the hypothesis that positive feedback is more motivating than negative feedback when far away from goal completion, but more so in textual than graphical form, while negative feedback is more motivating than positive feedback when near goal completion, but more so in graphical than textual form. Results seem to confirm that the presence of goal progress feedback is indeed more motivating than no feedback and that a three-way interaction effect exists between feedback valence, feedback visualization, and goal distance, but mixed trends are revealed in the directionality of the effects. Findings are discussed in the context of previous literature on goal progress feedback effects, statistical and theoretical limitations of the present study, and related research on the mechanisms of the motivation-cognition interaction.
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Am I There Yet?:

Probing the Effects of Goal Progress Feedback on Cognitive Motivation

Goals are constant directors of human behavior, as people’s lives are regularly guided by the pursuit of quantifiable objectives, but a ubiquitous problem arises in the difficulty of sustaining the motivation necessary for achieving those goals. For example, every year, thousands of New Year’s resolutions lists are topped by vows to lose weight, save money, spend more time with family, and a host of other self-improvement plans, but the majority of goal-setters struggle to follow through with these annual ambitions. With the recent explosion of mobile technologies, an abundance of fitness, budgeting, learning, and other self-tracking applications have been designed to help address this issue, each offering their own package of options, interfaces, and goal-setting aids, but little systematic research has been conducted to identify the features that are most effective in motivating users to persist in successfully accomplishing their goals. Informed by established theories and recent empirical findings from social and consumer psychology research on motivation, the present work addresses this knowledge gap by exploring the simultaneous effects of two goal progress feedback features that have been suggested to be of particular significance in influencing motivation at different goal distances: valence and visualization.

Goal Setting Theory of Motivation

One of the most well documented theories of motivation that have been developed over the past few decades of psychological research is the goal setting theory. Simply stated, the goal setting theory posits that the establishment of specific and appropriately challenging goals leads to better task performance by directing attention and effort toward goal-related activities, increasing persistence, and guiding the discovery or use of task-relevant knowledge and
strategies (Locke & Latham, 2002). This relationship has been consistently shown to be strongest when goal commitment is high and when goal progress feedback is present (Becker, 1978; Erez, 1977; Locke & Latham, 2002; Neubert, 1998).

**Dynamics of Self-Regulation Theory**

The mechanisms underlying the effects of goal progress feedback are varied but have been eloquently reconciled and summarized in a theory known as the dynamics of self-regulation (Fishbach, Zhang, & Koo, 2009). According to this theory, the motivational effects of feedback depend on how individuals mentally represent the meaning of their goal-related actions. On one hand, goal-related actions can be interpreted as an expression of commitment towards that goal. On the other hand, they can be interpreted as sufficient or insufficient progress towards it. By displaying the results of goal-related actions, feedback draws attention to individuals’ perceptions of their goal commitment or goal progress, and these in turn affect motivation to select and perform actions that are conducive to the achievement of relevant goals (Fishbach et al., 2009).

According to the dynamics of self-regulation theory, progress feedback contributes to the development of goal commitment through a variety of mechanisms. First, it indicates engagement. When individuals infer from progress feedback that they have been engaging in the pursuit of a goal, their subjective perception of the value of that goal increases, thereby reinforcing their motivation to pursue it (Higgins, 2006). Additionally, the perception of progress toward a goal increases the perceived attainability of that goal with respect to an individual’s abilities, and the resulting expectancy and sense of self-efficacy reinforce goal commitment as well (Schunk, 1995; Wigfield & Eccles, 2000). Finally, a third way in which progress feedback fosters goal commitment is through the sunk cost effect, or the common
tendency for people to continue an endeavor once an investment in money, effort, or time has been made, due to an overgeneralization of a “don’t waste” mentality (Arkes & Ayton, 1999). Together, these perceptions of engagement, attainability, and sunk costs created by progress feedback causes individuals to further commit to pursuing a goal.

Similarly, feedback also influences motivation when it is interpreted as an indicator of sufficient or insufficient progress towards a goal. According to the dynamics of self-regulation theory, the mechanisms underlying this relationship lie in the affective states induced by the feedback (Fishbach et al., 2009). When progress is deemed to be sufficient, positive affect is induced, and individuals feel good about the goal-related actions that they have already completed. This perception of adequate progress can then lead to a decrease in effort to pursue that goal because a satisfactory state has already been reached (Carver & Scheier, 1990; Martin, Ward, Achee, & Wyer, 1993). On the other hand, when progress is deemed insufficient, negative affect is induced. Consistent with established discrepancy theories (Carver & Scheier, 1990; Higgins, 1987), Fishbach et al. posit that the discomfort caused by a focus on the difference between current progress state and goal completion state motivates individuals to increase their efforts to close the gap between them (2009). As such, goal progress feedback can be either motivating or demotivating, depending on an individual’s affective response to it.

All together, the dynamics of self-regulation theory reconciles the variety of goal progress feedback effects by taking into account the role of different subjective interpretations of goal-related actions and linking together the various mechanisms through which those interpretations affect motivation. When goal commitment is increased by progress feedback and when negative affect is induced by a perceived lack of progress, motivation can be increased.
However, when positive affect is induced by a perceived adequacy of progress, motivation can be decreased.

**Motivation from Positive and Negative Feedback**

The dynamics of self-regulation theory provides a useful framework for understanding the effects of positive and negative goal progress feedback. Positive feedback draws attention to goal-related actions or results that have already been completed or achieved, while negative feedback draws attention to goal-related actions or results that are still missing or remain unachieved. As such, positive feedback should increase motivation by signaling goal commitment, while negative feedback should increase motivation by signaling a need for additional progress (Fishbach, Eyal, & Finkelstein, 2010; Fishbach, Koo, & Finkelstein, 2014).

This dichotomy opens up the question of when each valence of feedback should be most motivationally effective. According to the dynamics of self-regulation theory, since positive feedback functions through strengthening goal commitment, it should be most effective when goal commitment is weak or uncertain, which is most common when individuals are still far away from goal completion (Fishbach et al., 2010; Fishbach et al., 2014; Koo & Fishbach, 2008). Conversely, negative feedback should be most effective when individuals are near goal completion, as goal commitment is typically already certain by then and discrepancies between the current progress state and goal completion state need to be emphasized to avoid resting on laurels (Fishbach et al., 2010; Fishbach et al., 2014; Koo & Fishbach, 2008). These postulations are summarized in Koo and Fishbach’s small area hypothesis, which states that individuals striving toward a goal end state exhibit greater motivation when their attention is directed to whichever is smaller in size – their accumulated or remaining progress; in other words, positive
feedback is more motivating than negative feedback at the beginning of goal pursuit, while negative feedback is more motivating than positive feedback near the end of goal pursuit (2012).

Empirical evidence has shown that the small area hypothesis indeed holds true in a variety of domains, including lexical tasks in a controlled laboratory setting as well as in-field and hypothetical consumer uses of frequent buyer reward cards (Koo & Fishbach, 2012). Koo and Fishbach conducted several experiments to investigate the interaction effects of feedback valence and goal distance, and they consistently found that in conditions of low progress, self-rated and behavioral measures of motivation to achieve a given goal were higher when feedback was given on accumulated progress rather than entirely absent or focused on remaining progress (2012). Conversely, in conditions of high progress, self-rated and behavioral measures of motivation to achieve a given goal were higher when feedback was given on remaining progress rather than entirely absent or focused on accumulated progress. Additionally, this effect was statistically mediated by the illusion of fast progress (Koo & Fishbach, 2012). As such, both theory and empirical data suggest that feedback valence plays a significant role in affecting motivation through perceived goal progress and that its effects vary with respect to goal distance.

**Motivation from Goal Visualization**

Aside from the effects of positive and negative goal progress feedback, another line of research has also identified significant effects of goal visualization on motivation. Building on the well-established and empirically supported goal gradient hypothesis, which states that effort invested in reaching a goal increases with proximity to that goal (Hull, 1932; Kivetz, Urminsky, & Zheng, 2006), and previous distance perception research suggesting that visible objects are subjectively perceived as physically closer than equidistant hidden objects (Nasar, 1983; Nasar, Valencia, Omar, Chueh, & Hwang, 1985), Cheema and Bagchi conducted several experiments to
investigate how the ease of visualizing an end goal in progress feedback affects motivation in a variety of domains, including physical exertions of effort in controlled laboratory settings and in real swimming competitions as well as self-ratings of hypothetical commitments to save money and wait in consumer lines (2011). Their results consistently showed an interaction effect between goal visualization and goal distance such that effort and commitment were significantly greater when progress feedback consisted of an easy-to-visualize representation of the end goal state rather than a difficult-to-visualize representation of it, but only when near goal completion and not when far away from it. For example, graphical progress bars of wait time completion elicited greater ratings of willingness to continue waiting than textual reports of wait time completion when customers were close to reaching the full wait time, and this relationship was statistically mediated by perceptions of progress. In other words, seeing a progress bar increased people’s motivation because it made them feel like they were closer to their goal when they were almost there. All together, Cheema and Bagchi’s findings suggest that, just like feedback valence, feedback visualization plays a significant role in affecting motivation through perceived goal progress, and its effects vary with respect to goal distance.

**Effects of Feedback Valence, Feedback Visualization, and Goal Distance**

Although a substantial body of empirical research has been conducted on either the separate effects of feedback valence, feedback visualization, and goal distance or the interaction effects of one of the feedback features with goal distance, very few studies have specifically attempted to examine the interaction effects of all three variables. To date, one of the only experiments to explicitly manipulate all three variables is an online study conducted by Choe, Lee, Munson, Pratt, and Kientz on the effects of goal progress feedback on self-efficacy (2013). In this experiment, participants were asked to read a description of a hypothetical scenario in
which they were given a pedometer to monitor their step count towards a daily goal of 10,000 steps and asked to rate how confident they were that they could achieve this goal after being presented with an image of feedback on their hypothetical goal progress. The two levels of feedback valence used in the study were positive (how much progress had already been achieved) and negative (how much progress was still missing until goal completion), the two levels of feedback visualization were textual (numbers and words only) and graphical (numbers and words along with a two-colored progress bar), and the two levels of goal distance were far (25% of the way to goal completion) and near (75% of the way to goal completion). Using a mixed-design in which each participant received one type of feedback in both the far and near goal conditions in random order, Choe et al. found a main effect of valence such that positive feedback elicited greater self-efficacy than negative feedback, a main effect of visualization such that graphical feedback elicited greater self-efficacy textual feedback, and a main effect of goal distance such that the near condition elicited greater self-efficacy than the far condition. No interaction effects of the three variables were reported from the study.

Though informative of subjective cognitive reactions to goal progress feedback, Choe et al.’s experiment carries several limitations. First, the lack of a control condition did not allow the researchers to establish a baseline measure of self-efficacy or motivation without any feedback. Additionally, the convenient use of hypothetical ratings of self-efficacy in an online study does not necessarily provide information on intended or actual behavior. Although self-efficacy has been theorized to be a factor in motivation and empirically found to influence performance in contexts such as classroom achievement (Bandura, 1997; Schunk, 1982; Schunk, 1985), hypothetical ratings of it cannot be used as a proxy measure for motivation itself. As such, the results from Choe et al. are difficult to interpret with respect to established
psychological theories and recent empirical data on the effects of goal progress feedback on motivation per se. Despite these limitations however, the experimental variables and mixed-design used by Choe et al. provide a useful starting template for the present study.

**Present Research**

Building on the existing literature, the present research addresses the general question of how goal progress feedback affects motivation to expend cognitive effort towards a set goal, while specifically exploring the simultaneous effects of valence and visualization as well as the moderating role of goal distance. A controlled laboratory experiment was conducted to test the hypotheses that goal progress feedback is more motivating than no feedback and that there is a three-way interaction effect of feedback valence, feedback visualization, and goal distance. Based on the dynamics of self-regulation theory and small area hypothesis, positive feedback was predicted to be more motivating than negative feedback when far away from goal completion, and negative feedback was predicted to be more motivating than positive feedback when near goal completion. However, because graphical visualizations of goal progress inherently convey information about both achieved and missing progress (despite making one more visually salient than the other), the motivational effects of positive feedback were predicted to be greater in textual than graphical form when far away from goal completion, as visually deducible information about missing progress may counteract the effects of perceived achievement. In contrast, the motivational effects of negative feedback were predicted to be greater in graphical than textual form when near goal completion because of the increased ease in visualizing the end goal as well as the increased salience of discrepancy between one’s current progress state and the goal completion state.
Method

Participants

A total of 120 undergraduate students (ages 18-22, 80 female) with no previous knowledge about the study were voluntarily recruited from Princeton University by email invitation. All participants were compensated with $8 for up to half an hour’s time of participation plus an additional $2 if they achieved a pre-specified performance goal.

Design

The experiment employed a 2 x 2 x 2 mixed design with three categorical independent variables (IV) – feedback valence, feedback visualization, and goal distance – in addition to a control condition. Feedback valence and feedback visualization were between-subject variables, while goal distance was a within-subject variable. The control condition consisted of no feedback. Primary dependent variables (DV) were time spent on solvable trials and time spent on unsolvable trials.

IV: Feedback Valance. The two levels of feedback valance were termed “positive” and “negative.” Positive feedback consisted of explicit information about how much progress the participant had already achieved at any given point during the experimental task. Negative feedback consisted of explicit information about how much progress the participant had remaining with respect to a specific performance goal at any given point during the task.

IV: Feedback Visualization. The two levels of feedback visualization were termed “textual” and “graphical.” Textual feedback consisted of the words “N points achieved” or “N points to go” printed at the top of the screen on every trial during the experimental task, with N being an accurate report of the participant’s progress at any given point in time. Graphical feedback consisted a progress bar that spanned across the screen underneath the equivalent
textual feedback that was printed at the top. As was the case in Choe et al. (2013), both levels of feedback visualization included textual feedback, and the only difference was the presence or absence of a corresponding progress bar.

**IV: Goal Distance.** The two levels of goal distance were far and near, defined with respect to a point value that was pre-specified as the performance goal for the experimental task. The far condition consisted of the second trial (Trial 2) and the near condition consisted of the second to last trial (Trial 36) with the assumption that participants’ progress toward the goal would be very minimal on the second trial and substantially closer to completion by the time they reached the second to last trial.

**DV: Time Spent on Solvable Trials.** An individual measure of each participant’s ability to solve anagrams of the difficulty level in the experiment was collected by measuring the amount of time he/she spent on each solvable anagram trial and calculating their mean.

**DV: Time Spent on Unsolvable Trials.** Motivation, or persistence, was operationalized as the amount of time that participants spent on unsolvable anagram trials in the experiment. Longer amounts of time were interpreted as reflecting greater persistence and motivation, while shorter amounts of time were interpreted as reflecting lesser persistence and motivation.

**Experimental Task**

Since performance and persistence on anagram puzzles have been used as classic measures of motivation in a number of previous laboratory experiments (Goldsmith & Dhar, 2013; Iyengar & Lepper, 1999; Shah, Higgins, & Friedman, 1998), a game consisting of a series of anagram puzzles was developed for the present study. Several iterations of the experimental task were conducted with pilot participants to identify a length and difficulty level that were appropriately challenging but could still reasonably be completed within 30 minutes. The final
task consisted of the 37 five-letter anagrams listed in the Appendix. Thirty-five of them were solvable with only one valid solution, and the other two were unsolvable (with no valid solutions in existence). Solutions to all solvable anagrams were common English words, and all solvable anagrams were adapted from Adams, Stone, Vincent, and Muncer (2011).

The experiment was programmed in Matlab and executed on a 15-inch Apple Macbook Pro laptop with non-retina display. On each trial, a scrambled word was presented in the middle of the screen in all capital letters. Participants were instructed to solve each anagram by typing the unscrambled version of the word into a case-insensitive text box underneath it and pressing the ‘Return’ button to submit their answer. If their answer was correct, they received 100 points and the experiment automatically proceeded to the next trial as a new scrambled word appeared in the middle of the screen. If their answer was incorrect, they did not receive or lose any points, and the experiment stayed on the same trial. Participants were allowed an infinite number of attempts to solve each anagram. However, they were also given the option to give up on any trial that they could not solve by clicking a ‘SKIP’ button on the bottom right hand corner of the screen. To incentive participants to give each and every trial their best effort, they were informed that they could not return to any skipped anagrams. Accurate goal progress feedback was presented and updated in real time at the top of the screen in non-control conditions and was absent in the control condition, as illustrated in Figures 1A, 1B, 1C, 1D, and 1E.
**Figure 1A.** Sample experimental task trial screens from Control condition.

**Figure 1B.** Sample experimental task trial screens from Positive Textual condition.

**Figure 1C.** Sample experimental task trial screens from Negative Textual condition.
Between-subject conditions were randomly assigned to each participant, and the order of the 35 solvable anagrams was randomized for each participant, while the unsolvable anagrams were always fixed on Trial 2 and Trial 36, but the order of unsolvable anagrams in these two trials was randomized as well.

Procedure

The experiment was conducted in a controlled laboratory setting. To set a standard goal, all participants were told before starting the task that they would receive a $2 bonus if they
achieved 3500 points by the end of the experiment. (Unbeknownst to participants, this was only achievable if they correctly solved every solvable anagram in the experiment.) Participants were explicitly told that every anagram was solvable and that there were a limited number of trials in the task, but they were not informed of the exact number of anagrams in total. As such, participants could not calculate how many trials they could skip without compromising the $2 bonus and were thus incentivized to give each and every trial their best effort. After completing the task, participants were debriefed about the true nature of the experiment and compensated with the appropriate amount of payment based on their performance scores from the task.

**Analysis**

To ensure that the “near” condition of goal distance was sufficiently satisfied, any participants with final performance scores less than 3000 were excluded from the analysis. As a result, 20 participants were excluded. However, participants were randomly assigned conditions in such an order that ensured exactly 20 participants would be included in the analysis for each of the 5 between-subject groups.

All statistical analyses were run using Matlab or StatView software. A one-way between-subject ANOVA was first conducted with feedback type as the predictor variable (control, positive textual, negative textual, positive graphical, and negative graphical) to evaluate whether group means for time spent on solvable anagrams (a rough proxy for the subjective difficulty of the task for each individual) was significantly different between conditions.

Next, a one-way between-subject ANOVA was conducted with feedback type as the predictor variable to test for significant differences between group means for time spent on unsolvable anagrams. A planned one-tailed t-test was then conducted between the control group and all other experimental groups combined on the mean time spent on unsolvable anagrams to
evaluate whether the absence vs. presence of feedback had a significant effect on persistence. Subsequently, 4 individual planned one-tailed t-tests were conducted between the control group and each of the other experimental feedback groups to analyze the specific effects of each feedback type in comparison to no feedback. Mean time spent on unsolvable anagrams was calculated for each participant as the average of time spent on Trial 2 and time spent on Trial 36.

Finally, two-way between-subject ANOVAs with repeated measures were conducted on the mean raw time spent on unsolvable anagrams and on the mean corrected time spent on unsolvable anagrams with feedback type as the predictor variable (excluding the control group) to evaluate the main and interactive effects of feedback valence, feedback visualization, and goal distance on persistence. Corrected times for each participant were calculated by dividing the amount of time that he/she spent on each unsolvable trial by the mean time that he/she spent on all solvable trials. This was done to account for individual variation in anagram-solving ability.

**Results**

**Mean Time on Solvable Anagrams**

As shown in Figure 2, a one-way between-subject ANOVA revealed no statistically significant difference between group means for time spent on solvable anagrams ($F(4, 95) = 1.281, p = 0.2828$). Means and standard deviations are presented in Table 1.
Figure 2. Group means and standard errors for time spent on solvable trials.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Count</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>20</td>
<td>20.934</td>
<td>9.128</td>
<td>2.041</td>
</tr>
<tr>
<td>Positive Textual</td>
<td>20</td>
<td>19.888</td>
<td>9.755</td>
<td>2.181</td>
</tr>
<tr>
<td>Negative Textual</td>
<td>20</td>
<td>23.893</td>
<td>13.086</td>
<td>2.926</td>
</tr>
<tr>
<td>Positive Graphical</td>
<td>20</td>
<td>16.878</td>
<td>8.906</td>
<td>1.991</td>
</tr>
<tr>
<td>Negative Graphical</td>
<td>20</td>
<td>21.123</td>
<td>8.360</td>
<td>1.869</td>
</tr>
</tbody>
</table>

Group sample sizes, means, standard deviations, and standard errors for time spent on solvable trials (in seconds).

Mean Time on Unsolvable Anagrams

A one-way between-subject ANOVA revealed no statistically significant difference in group means for time spent on unsolvable anagrams overall \((F(4, 95) = 1.254, p = 0.2934)\).

However, a planned one-tailed t-test revealed a marginally significant difference between group means for the control condition and all other feedback conditions combined \((t(98) = 1.5424, p = 0.0631)\). As shown in Figure 3, subsequent one-tailed t-tests revealed that the positive graphical feedback group mean was significantly greater than the control group mean \((t(38) = 1.9746, p = \)
0.0278), while the negative textual feedback group mean and negative graphical feedback group mean were both marginally significantly greater than the control group mean ($t(38) = 1.4602$, $p = 0.0762$; $t(38) = 1.4590$, $p = 0.0764$). No statistically significant difference was found between the control group mean and the positive textual feedback group mean ($t(38) = 0.5342$, $p = 0.2982$). Means and standard deviations are presented in Table 2.

![Figure 3](image_url)

**Figure 3.** Group means and standard errors for time spent on unsolvable trials (in seconds), split by feedback type.

**Table 2**

<table>
<thead>
<tr>
<th>Group Type</th>
<th>Count</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>20</td>
<td>120.49</td>
<td>39.036</td>
<td>8.729</td>
</tr>
<tr>
<td>Positive Textual</td>
<td>20</td>
<td>127.54</td>
<td>44.236</td>
<td>9.891</td>
</tr>
<tr>
<td>Negative Textual</td>
<td>20</td>
<td>147.97</td>
<td>74.575</td>
<td>16.676</td>
</tr>
<tr>
<td>Positive Graphical</td>
<td>20</td>
<td>163.15</td>
<td>88.376</td>
<td>19.762</td>
</tr>
<tr>
<td>Negative Graphical</td>
<td>20</td>
<td>153.80</td>
<td>94.350</td>
<td>21.097</td>
</tr>
</tbody>
</table>

Group sample sizes, means, standard deviations, and standard errors for time spent on unsolvable trials (in seconds), split by feedback type.
Effects of Feedback Valence, Feedback Visualization, and Goal Distance

As shown in Figure 4, a two-way between-subject ANOVA with repeated measures on group means for raw time spent on unsolvable trials revealed a significant main effect of goal distance such that mean time spent on Trial 36 was greater than mean time spent on Trial 2 ($F(1, 76) = 5.742, p = 0.0190$). No other significant main effects were found for valence ($F(1, 76) = 0.102, p = 0.7509$) or for visualization ($F(1, 76) = 1.417, p = 0.2375$). No significant two-way interaction effects were found for valence and visualization ($F(1, 76) = 0.732, p = 0.3949$), for valence and goal distance ($F(1, 76) = 2.617, p = 0.1099$), or for visualization and goal distance ($F(1, 76) = 0.036, p = 0.8499$). No significant three-way interaction effect was found ($F(1, 76) = 1.334, p = 0.2518$). Means and standard deviations are reported in Table 3.
Figure 4. Group means and standard errors for raw time spent on unsolvable trials (in seconds), split by feedback valence, feedback visualization, and goal distance.

Table 3

<table>
<thead>
<tr>
<th>Feedback Valence</th>
<th>Feedback Visualization</th>
<th>Goal Distance</th>
<th>Count</th>
<th>Mean (Seconds)</th>
<th>Std. Dev.</th>
<th>Std. Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td>Graphical</td>
<td>Trial 2</td>
<td>20</td>
<td>136.416</td>
<td>70.237</td>
<td>15.705</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trial 36</td>
<td>20</td>
<td>171.186</td>
<td>145.655</td>
<td>32.570</td>
</tr>
<tr>
<td>Negative</td>
<td>Textual</td>
<td>Trial 2</td>
<td>20</td>
<td>113.071</td>
<td>57.427</td>
<td>12.841</td>
</tr>
<tr>
<td>Positive</td>
<td>Graphical</td>
<td>Trial 2</td>
<td>20</td>
<td>151.791</td>
<td>79.208</td>
<td>17.711</td>
</tr>
<tr>
<td>Positive</td>
<td>Graphical</td>
<td>Trial 36</td>
<td>20</td>
<td>174.504</td>
<td>122.807</td>
<td>27.460</td>
</tr>
<tr>
<td>Positive</td>
<td>Textual</td>
<td>Trial 2</td>
<td>20</td>
<td>128.750</td>
<td>68.557</td>
<td>15.330</td>
</tr>
<tr>
<td>Positive</td>
<td>Textual</td>
<td>Trial 36</td>
<td>20</td>
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</table>

Group sample sizes, means, standard deviations, and standard errors for raw time spent on unsolvable trials (in seconds), split by feedback valence, feedback visualization, and goal distance.

As shown in Figure 5, a two-way between-subject ANOVA with repeated measures on group means for corrected time spent on unsolvable trials revealed a marginally significant main effect of goal distance such that mean time spent on Trial 36 was greater than mean time spent on Trial 2 \((F(1, 76) = 3.427, p = 0.0680)\) as well as a significant 3-way interaction effect between feedback valence, feedback visualization, and goal distance \((F(1, 76) = 4.571, p = 0.0357)\). No other significant main effects were found for valence \((F(1, 76) = 1.674, p = 0.1996)\) or for visualization \((F(1, 76) = 1.362, p = 0.2469)\). No significant two-way interaction effects were found for valence and visualization \((F(1, 76) = 2.500, p = 0.1180)\), for valence and goal distance \((F(1, 76) = 0.946, p = 0.3339)\), or for visualization and goal distance \((F(1, 76) = 0.286, p = 0.5942)\). Means and standard deviations are reported in Table 4.
Figure 5. Group means and standard errors for corrected time spent on unsolvable trials, split by feedback valence, feedback visualization, and goal distance.

Table 4

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<th>Std. Err.</th>
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<td>2.456</td>
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Group sample sizes, means, standard deviations, and standard errors for corrected time spent on unsolvable trials, split by feedback valence, feedback visualization, and goal distance.
Discussion

As expected, the lack of a statistically significant difference between group means for time spent on solvable trials suggests that the task was of comparable difficulty to subjects in all conditions. This preliminary check validated our subsequent focus on group means for time spent on unsolvable trials as a measure of participants’ motivation rather than participants’ anagram-solving abilities per se.

The marginally significant difference between group means for the control condition and all other feedback conditions combined on time spent on unsolvable anagrams lends a hint of support for the initial hypothesis that the presence of goal progress feedback in general has some motivational effect. The statistically significant difference between group means for the control condition and positive graphical feedback condition further supports this hypothesis, as do the marginally significant differences between group means for the control and negative textual feedback conditions as well as for the control and negative graphical feedback conditions. While these comparisons show a trend towards the hypothesized motivational effect of goal progress feedback, the inability to detect more statistically significant differences between the control group and each of the other experimental feedback groups may be due to a small sample size and lack of statistical power.

Having established, at least with minimal support, that the presence of goal progress feedback may indeed have a more motivational effect than no feedback, subsequent tests that excluded the control group presented a more nuanced view of how different features of feedback affect motivation at different points during the goal-striving process. The statistically significant main effect and marginally statistically significant main effect found for goal distance in our analyses of the mean raw time and mean corrected time spent on unsolvable trials suggest with
consistency that goal progress feedback is generally more motivational when near goal completion than when far away from it. However, the statistically significant three-way interaction effect between feedback valence, feedback visualization, and goal distance reveals that there is more variability in the effects of different types of goal progress feedback at each goal distance.

Analyses of the mean raw time spent on unsolvable trials reveal that numerically, when far away from goal completion, positive feedback appeared to be more motivational than negative feedback in both textual and graphical forms. The relative difference between the group means for positive and negative feedback in both visualization conditions were about the same, but the absolute value of group means were greater for graphical than textual conditions under both valences when far away from goal completion. In contrast, when near goal completion, negative feedback was more motivational than positive feedback in textual form but essentially equivalently motivational in graphical form. Taken together, these numerical analyses show trends supporting the original hypothesis that positive feedback may be more motivational than negative feedback when far away from goal completion and negative feedback may be more motivational than positive feedback when near goal completion, but they do not support the hypothesized differences between textual and graphical feedback within those relationships between valences. While positive textual feedback was hypothesized to be more motivational than positive graphical feedback when far away from goal completion and negative graphical feedback was hypothesized to be more motivational than negative textual feedback when near goal completion, the opposite trends were observed in numerical analyses of mean raw time spent on unsolvable trials.
Similarly, analyses of the mean corrected time spent on unsolvable trials reveal that numerically, when far away from goal completion, positive feedback appeared to be more motivational than negative feedback in general, and this effect was more pronounced in graphical than textual form. In contrast however, when near goal completion, negative feedback appeared to be more motivational than positive feedback when presented in textual form, while positive feedback appeared to be more motivational than negative feedback when presented in graphical form. Taken together, numerical analyses of mean corrected time spent on unsolvable trials show almost all of the same trends as those suggested by the numerical analyses of mean raw times spent on unsolvable trials with the exception that positive graphical feedback appeared to be more motivational than any other condition when near goal completion.

As a whole, the results from this experiment provide some statistical support for the hypothesis that there is a three-way interaction effect between feedback valence, feedback visualization, and goal distance. However, numerical trends in the data vary with respect to the hypothesized direction of differences between conditions. When far away from goal completion, trends in both mean raw times and mean corrected times support the hypothesized advantage of positive over negative feedback but not the hypothesized advantage of textual over graphical forms. When near goal completion, trends in mean raw time inconsistently support the hypothesized advantage of negative over positive feedback but do not support the hypothesized advantage of graphical over textual forms of negative feedback, and trends in mean corrected time do not support any of the hypothesized effects.

**Reconciliation with Previous Literature**

When considered in the context of established motivation theories, several parts of the present findings appear to be consistent with previous literature. The marginally significant and
statistically significant effects of goal progress feedback over no feedback support Locke and Latham’s theory on the role of feedback in the motivational effects of goal setting processes (2002). Similarly, the main effects of goal distance found in this study add support to the body of literature surrounding the goal gradient hypothesis and the increased exertion of effort when nearing goal completion (Hull, 1932; Kivetz et al., 2006). In addition, the numerically apparent advantage of positive feedback over negative feedback in both visualization forms when far from goal completion seem to be consistent with Koo and Fishbach’s small area hypothesis (2012). Likewise, the numerically apparent advantage of positive graphical feedback over positive textual feedback when near goal completion seem to be consistent with Cheema and Bagchi’s findings on the interaction effect of goal visualization and goal distance on motivation (2011).

However, other aspects of the present findings appear to be at odds with previous literature. For example, the lack of a clear motivational advantage of negative feedback over positive feedback in the near goal condition seems inconsistent with Koo and Fishbach’s small area hypothesis (2012). Though strong conclusions cannot be confidently drawn from the present data, differences between theoretically hypothesized results and the present empirical findings are likely due to a number of statistical and theoretical limitations of the current study.

**Statistical Limitations**

As discussed, the small sample size in the experiment inherently limited the statistical power of all tests. As such, future experiments of the same design should recruit a greater number of participants per condition. Alternatively, the current experiment used a between-subject design to examine the effects of goal progress feedback valence and visualization, but another potentially fruitful method of investigating the same effects would be to conduct an
analogous experiment using a within-subject design for all independent variables. Such a design would lend more statistical power to analyses on the resulting data.

In addition to the statistical weaknesses of a small sample size, the use of reaction times as a dependent measure in the experiment was limiting as well, as reaction times are generally very noisy behavioral measures. In particular, the use of reaction times on one individual trial of unsolvable anagrams in each goal distance condition severely undermined the potential role of uncontrolled factors that are not directly related to our primary variable of interest (motivation), such as participants’ wandering attentions, typing speeds, and motor coordination abilities with respect to the laptop track pad. Compounded with the limited sample size per condition in this experiment, the effects of noisy reaction times can be seen in the noticeably large differences in variance between feedback groups.

Moreover, the use of ratios to account for individual variability in anagram-solving ability in corrected time spent on unsolvable anagrams may be problematic as well, as division drastically inflates perceived differences, especially when the mean time spent on solvable anagrams is particularly low and the mean time spent on unsolvable anagrams is particularly high. As such, the combination of small sample sizes, noisy reaction time measures, and ratio calculations requires that ample caution be taken in interpreting the results from this experiment.

**Theoretical Limitations**

In addition to the statistical limitations imposed by the design of the experiment, theoretical limitations of the present research must also be recognized. First, the scope of the present study is limited to the effects of goal progress feedback in situations where the goal is static, externally imposed, and performance-oriented. As such, the present data do not provide direct insight into the effects of goal progress feedback in other situations where the goal is
dynamic, internally imposed, or process-oriented. In other words, the motivational trends that arise in an experimental task where the goal is an unchanging target point value that was pre-determined by a researcher may not be applicable to tasks in which the goal fluctuates with respect to time or effort, is selected or defined by the participant himself/herself, or focuses on the qualitative learning or mastery of a skill rather than the achievement of a quantifiable performance objective. Given these limitations, further research is needed to investigate potentially analogous effects of goal progress feedback in a more diverse range of goal scenarios.

Additionally, the present study only examined the effects of goal progress feedback in the form of a raw points system and not percentages of current progress in relation to a goal. Since the raw points system used in the experiment was set to range from 0 to 3500 points, it is still unclear whether the effects of feedback valence, feedback visualization, and goal distance suggested by the present data would also be applicable to goal progress feedback that is presented in the form of ratios or otherwise numerically constrained systems. For example, the same motivational trends for valence, visualization, and goal distance may not necessarily arise if a progress mark of “100 points achieved” were presented as “100 out of 3500 points achieved” or “2.85% achieved” instead, as each feedback system draws attention to different aspects of goal progress that may in turn have different effects on motivation. Again, additional research is needed to clarify the extent to which the feature effects suggested by this study are generalizable to other systems of feedback presentation.

Finally, because the experimental task was only a 30-minute puzzle game administered in a controlled laboratory setting, external validity is limited in terms of the time span, abstraction level, and domain of goal pursuit. For example, it is unclear how the effects of goal distance would differ for the pursuit of more long-term objectives such as those that require a day, a
week, a month, or even a year to complete. Additionally, human goals are often not as concretely defined as the numerical target that was used in the present experiment. Common abstract goals include “get a better job,” “get fit,” “get organized,” and other resolutions that are not necessarily measurable or explicitly defined by number values. As such, it is unclear how goal progress feedback would work in such scenarios. Even in cases where goals can be quantified, such as those in which an exerciser uses a physical activity tracker to monitor the number of miles that he/she has walked or the number of calories that he/she has burned with respect to a daily fitness goal, motivation to expend physical effort may not be affected in the same way as motivation to expend cognitive effort in an anagram-solving game. Field studies will need to be conducted with users in a variety of naturalistic settings to glean more externally valid insights on the nature of goal progress feedback’s effects on motivation in different domains.

**Mechanisms of Motivation-Cognition Interaction**

In addition to observing the empirical effects of goal progress feedback on behavior, understanding the theoretical relationship between motivation and cognition can also yield richer insights into the mechanisms underlying the effects of feedback. From a cognitive neuroscience perspective, motivation to pursue a goal is often thought of as a decision that results from an analysis between the subjective costs and expected value of effort investment (Braver et al., 2014; Dixon & Christoff, 2012; Kool & Botvinick, 2014; Kurzban, Duckworth, Kable, & Myers, 2013; Shenhav, Botvinick, & Cohen, 2013). This interpretation is based on a wealth of recent behavioral and neural evidence suggesting that people are inherently biased towards an avoidance of cognitive demand because effort is both intrinsically and subjectively costly (Botvinick, 2007; Kool, McGuire, Rosen, & Botvinick, 2010; Kool, McGuire, Wang, &
Botvinick, 2013; Westbrook, Kester, & Braver, 2013). As such, the decision to exert effort is only made when the subjective benefits are thought to outweigh the subjective costs.

This cost/benefit analysis framework of cognitive motivation is also consistent with previous research on the role of value in the goal gradient hypothesis. Both theoretical and empirical work have suggested that the subjective value of a goal can vary with respect to distance from the goal in such a way that value increases as proximity to the goal increases (Heath, Larrick, & Wu, 1999; Liberman & Förster, 2008). When viewed in this context, the increases in effort that are often observed with increases in goal proximity can be interpreted to be results of increases in marginal benefit (Heath et al., 1999). Recent neuroimaging experiments on goal striving behavior in rats have even identified specific neurotransmitters and brain areas that seem to encode or respond to these changing subjective values as goal progress and proximity increase (Howe, Tierney, Sandberg, Phillips, & Graybiel, 2013; Ma, Hyman, Phillips, & Seamans, 2014). As such, the subjective costs vs. expected value view of motivation is a profoundly supported one that can be used to inform or expand our understanding of the effects of goal progress feedback.

In the present study, participants could easily have chosen to skip all anagram trials if they wanted to avoid cognitive demand altogether, and they would still have received $8 for compensation. Barring any social repercussions of such uncooperative behavior however, their apparent decision to expend the effort needed to solve as many anagrams as they did and to spend the amount of time that they did on the unsolvable anagrams suggests that the subjective value of achieving the goal was greater than the subjective cost of trying. Under the cost/benefit analysis view of motivation, goal progress feedback in the present experiment could then be hypothesized to have affected motivation in one of two ways: it could have raised the subjective
value or lowered the subjective cost of expending cognitive effort. Given that subjective value has been theorized and empirically shown to vary with goal distance in previous literature, another potentially fruitful direction of research could be to investigate whether and how goal progress feedback explicitly affects subjective perceptions of goal value.

Although the present research only begins to probe the effects of goal progress feedback within a limited range of circumstances, it does help to raise a broad range of related research questions about the variability and extent of feedback effects, and it sets the stage for a large proliferation of future studies that will be required to identify and elucidate more nuances in the mechanisms underlying goal progress feedback’s effects on motivation.
References


Appendix

List of Anagrams

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<thead>
<tr>
<th>Anagram</th>
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</tr>
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Please use this form to indicate the relationship between previous work and your senior thesis and to indicate whether your thesis involved collaboration with others.

Indicate below whether there is any overlap between your senior thesis and earlier work that you did for junior reports, junior papers, or papers for various courses.

Overlap

No Overlap X

If you checked the box indicating that there is overlap between your senior thesis and previous work, please describe the overlap on a separate page, and include it within the thesis after this form.

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Yes _____ X No _____

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