The Relationship Between Dual Feedback and Self-Perception in Amplitude Discrimination Task Performance

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Feedback and self-perception are often studied in relation to task performance as they are often associated with observable differences in performance. However, the way self-perception and feedback may affect each other and an individual has yet to be fully understood. Therefore, the purpose of this study is to determine whether there is a relationship between different types of feedback and subject self-perception, and to understand the effects of using different feedback types. A group of 39 young adults performed a series of amplitude discrimination tasks and were provided with three feedback conditions and completed a survey detailing their perception of their performance and the feedback provided. Results indicated that there is a difference in perception of feedback types, though there was no significant difference in performance between the feedback conditions. Additionally, there was some evidence that a pattern exists by which subjects with lower self-efficacy scores may be more susceptible to performance changes as feedback conditions change. These findings suggest that subjects are responsive to feedback, and that this responsivity could be related to subjects' self-perception.

Introduction

Human task performance has been of great scientific interest for much of history, and feedback is often studied in relation to such topics. Feedback in this study is defined as the provision of indicators or cues which reinforce effective performance or suggest changes must be made to correct performance. Many studies have suggested that feedback has been associated with increased participant motivation and enhanced performance [1-3] . A study conducted by E. F. Stone and D. L. Stone manipulated subjects' exposure to one or multiple sources of feedback and assessed their perceived performance and perceived accuracy of feedback. The study found that multiple feedback sources were able to increase subjects' self-perception of their performance and that more sources of favorable feedback were thought to be more accurate and more effective at increasing self-perception of performance [4].

Based on this study and others, it is possible that the way feedback impacts self-perception of performance could be the mechanism by which performance is itself enhanced. However, a study conducted by Stringer and Heath suggests that self-perception measures may not be tied to performance in this way [5]. This view of self-perception as a weak predictor of performance is demonstrated in the Dunning-Kruger effect. The Dunning-Kruger effect observes that high-performers often underestimate their ability, while low-performers tend to overestimate ability on performance tasks [6]. These conflicting trends concerning the relationship between self-perception and performance may be changed in part by the presence of feedback.

Previous research has determined that performance on amplitude discrimination tasks as measured by the difference limen improves with feedback present [1]. Furthermore, correct feedback as opposed to all incorrect feedback produces greater positive change in performance [2,7]. However, all of these forms of feedback have been of a single type; an image was displayed after response to indicate either a correct or incorrect answer. The purpose of this study was twofold: to determine whether the use of multiple forms of feedback have different effects on amplitude discrimination task performance, and to investigate whether subject self-perception has a relationship with the way feedback impacts performance. We hypothesized that (1) the presence of dual feedback would produce better amplitude discrimination performance in both speed and accuracy than either feedback condition independently, (2) subjects with high self-efficacy measures would be less susceptible to performance change as a result of feedback, and (3) subjects' perceptions of their performance will change with the presence of different forms of feedback.

Methods

This study recruited n=39 subjects, 14 male and 25 female. The subjects were healthy individuals between the ages of 20 and 28. Participants were performed amplitude discrimination tasks using the Brain Gauge (Cortical Metrics, Carrboro, NC). The Brain Gauge hardware is a two-point vibrotactile simulator provided to each of the participants. It features two five-millimeter vibrating cylinders that are able to provide tactile stimulation to two adjacent fingers, typically the index and middle fingers. The software was downloaded onto participants' computers, and the Brain Gauge was attached via USB.

Participants were instructed to complete the protocol in a quiet location with no distractions. To determine measures of self-perception, two surveys were given; one survey was taken before amplitude discrimination testing, and the other was taken immediately following testing. Questions from both surveys were adapted from the New General Self-Efficacy Scale produced at Stanford University (Stanford University, Stanford, CA). The quantitative measure of self-efficacy is the method by which self-perception of participants is measured. Results from the first survey produced the overall self-efficacy score for each subject, and results from the second survey indicated self-perception as it related to performance on the amplitude discrimination tasks under each feedback condition.

After the first survey, participants completed three amplitude discrimination tasks. Each amplitude discrimination task was prepared in the Brain Gauge software such that participants were given instructions to determine which stimulus delivered to their two fingers was more intense than the other as quickly as possible. The Brain Gauge would then deliver a vibration to the fingertips for 240 milliseconds, and then the participant was prompted to respond with "left" or "right" using their mouse or arrows on the keyboard. After each response, each of the three tasks provided a different type of feedback or a combination of feedback types. Speed feedback recorded the time between the stimulus delivery to the brain gauge and the response time of the participant and reported a value on the screen in milliseconds after the response. The second type of feedback displayed a green "smiley" face if the response was correct, and a red "frowny" face if the response was incorrect. The first amplitude discrimination task used speed feedback only, the second used accuracy feedback only, and the third task had dual feedback in which both the speed and accuracy indications were displayed. After completing the three tasks, participants were instructed not to look at any data provided in the Brain Gauge software before completing the second survey.

Statistical analysis was conducted using two-tailed paired t-tests for significance to determine whether there were significant differences in the average difference limens between the three tasks. The null hypothesis was that there was no difference in accuracy or speed on amplitude discrimination tasks between the three feedback conditions. The alternative hypothesis was that there would be a difference in amplitude discrimination accuracy or speed for different feedback conditions. For tests of significance that were not conducted between feedback conditions, two-tailed unpaired t-tests were used. The null hypothesis was that there was no difference between groups, and the alternative hypothesis was that a difference existed between the groups. Significance was measured at $\alpha=0.05$. Additionally, survey results will be compiled into an overall self-efficacy score by adding together the numbers of the responses that participants chose. A higher self-efficacy score reflects that the individual has a high view of their abilities, whereas a lower self-efficacy score reflects the opposite.

Results

Amplitude Discrimination Tasks

Table 1 depicts the average difference limen (DL) and response time (RT) for each of the amplitude discrimination tasks. Each of the three different feedback conditions produced similar results both for DL and RT. Significance was determined through the use of two-tailed paired t-tests as displayed in Table 2 and Table 3. This indicated no significant difference between the mean DL and mean RT between feedback conditions.

	SO	CIO	Dual
Mean DL (μm)	46.72	44.54	45.33
Standard Deviation	26.22	24.49	22.63
Mean RT (ms)	384.95	417.32	392.45
Standard Deviation	175.80	244.30	211.10

Figure 1. *Mean and standard deviation DL and RT scores for each feedback condition . SO indicates the speed-only condition and CIO indicates the correct/incorrect-only condition.*

	SO	CIO	Dual
SO	-	0.14	0.98
CIO	-	-	0.47
Dual	-	-	-

Figure 2. *Feedback condition DL p-values from t-tests for significance.*

	SO	CIO	Dual
SO	-	0.66	0.78
CIO	-	-	0.88
Dual	-	-	-

Figure 3. *Feedback condition RT p-values from t-tests for significance.*

Figure 4 and Figure 5 show three box and whisker plots of DL and three plots of RT for each of the feedback conditions. The mean performance depicted looks largely the same between feedback conditions in each of the plots, yet there is a small decrease in variability between the individual feedback conditions (SO and CIO) and the dual feedback condition.

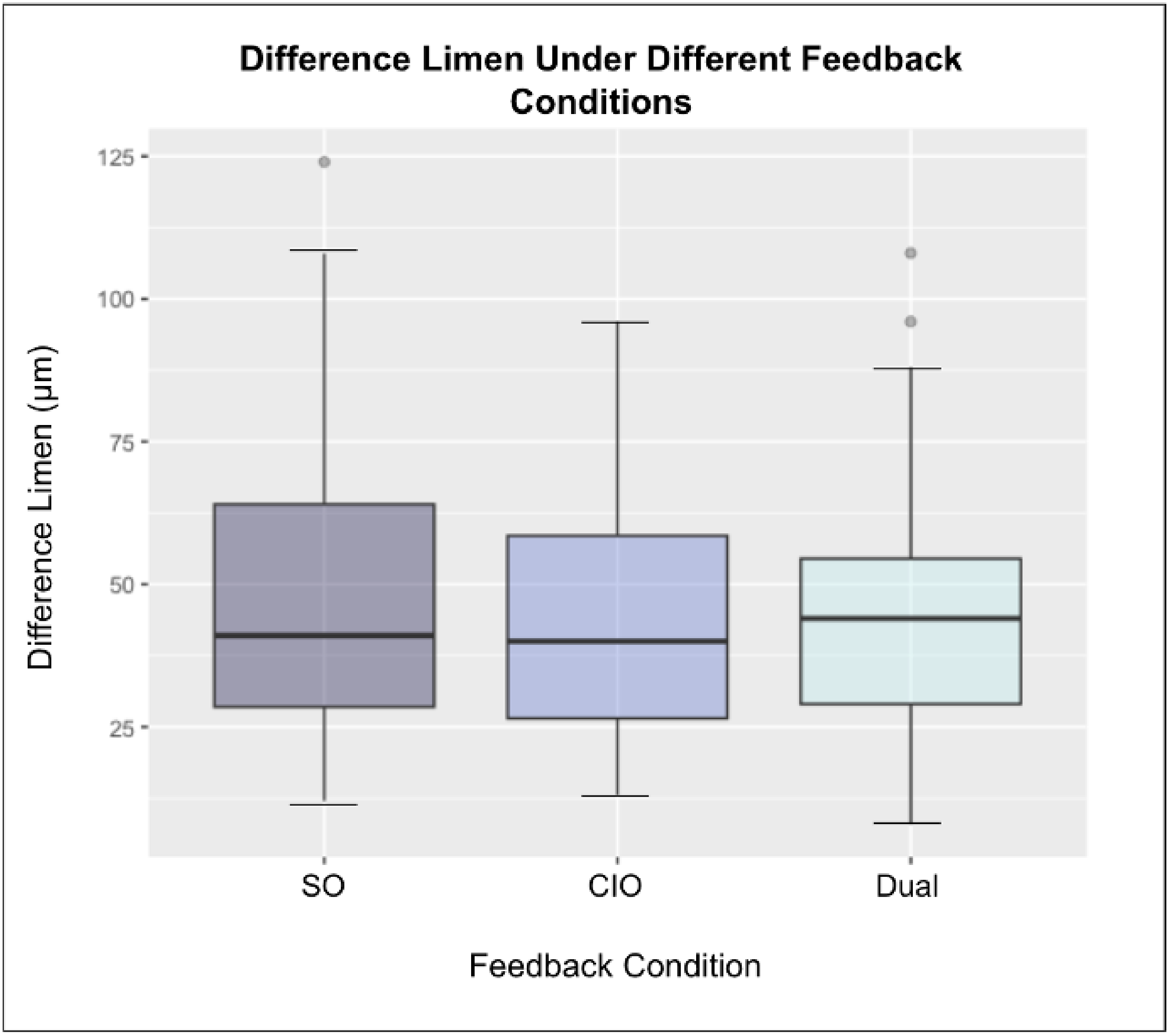

Figure 4. *Difference limen values and distributions for each feedback condition. SO indicates the speed-only condition and CIO indicates the correct/incorrect-only condition.*

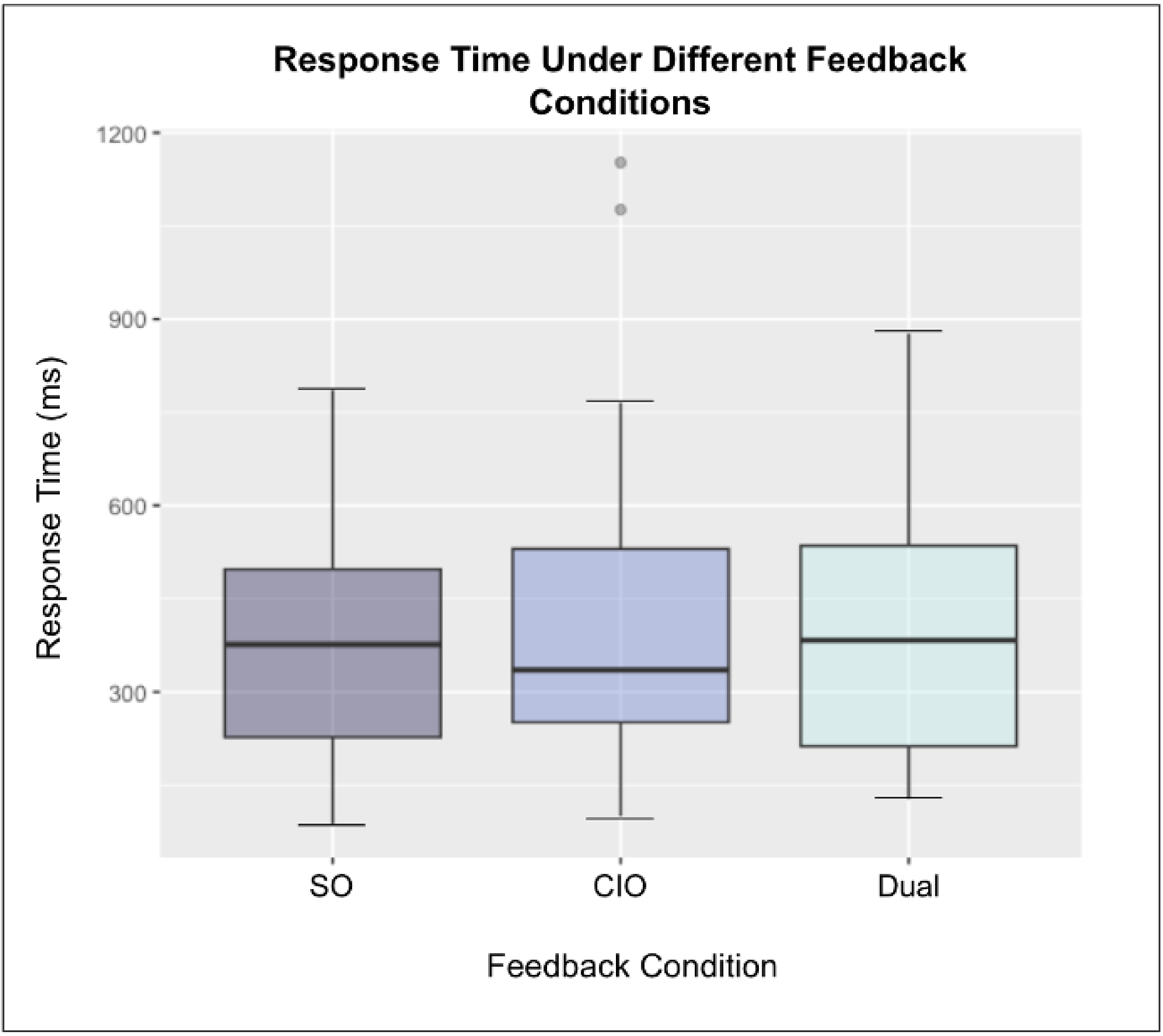

Figure 5. *Response time values and distributions for each feedback condition. SO indicates the speed-only condition and CIO indicates the correct/incorrect-only condition.*

Each subject had a best, middle, and worst performance for DL and RT that fell within one of the three feedback conditions. Figure 6 and Figure 7 provide a count of how many best, medium, and worst performances for DL and RT were associated with each feedback condition.

DL Performance	SO	CIO	Dual
Best	10	18	9
Middle	18	9	17
Worst	11	12	13

Figure 6. *Best, middle, and worst DL counts for each feedback condition.*

RT Performance	SO	CIO	Dual
Best	11	9	15
Middle	13	11	7
Worst	9	14	10

Figure 7. *Best, middle, and worst RT counts for each feedback condition.*

Additionally, the maximum change in DL from worst performance to best performance (ΔDL) was analyzed as a measure of subject sensitivity to feedback. Figure 8 is a box and whisker plot of these values.

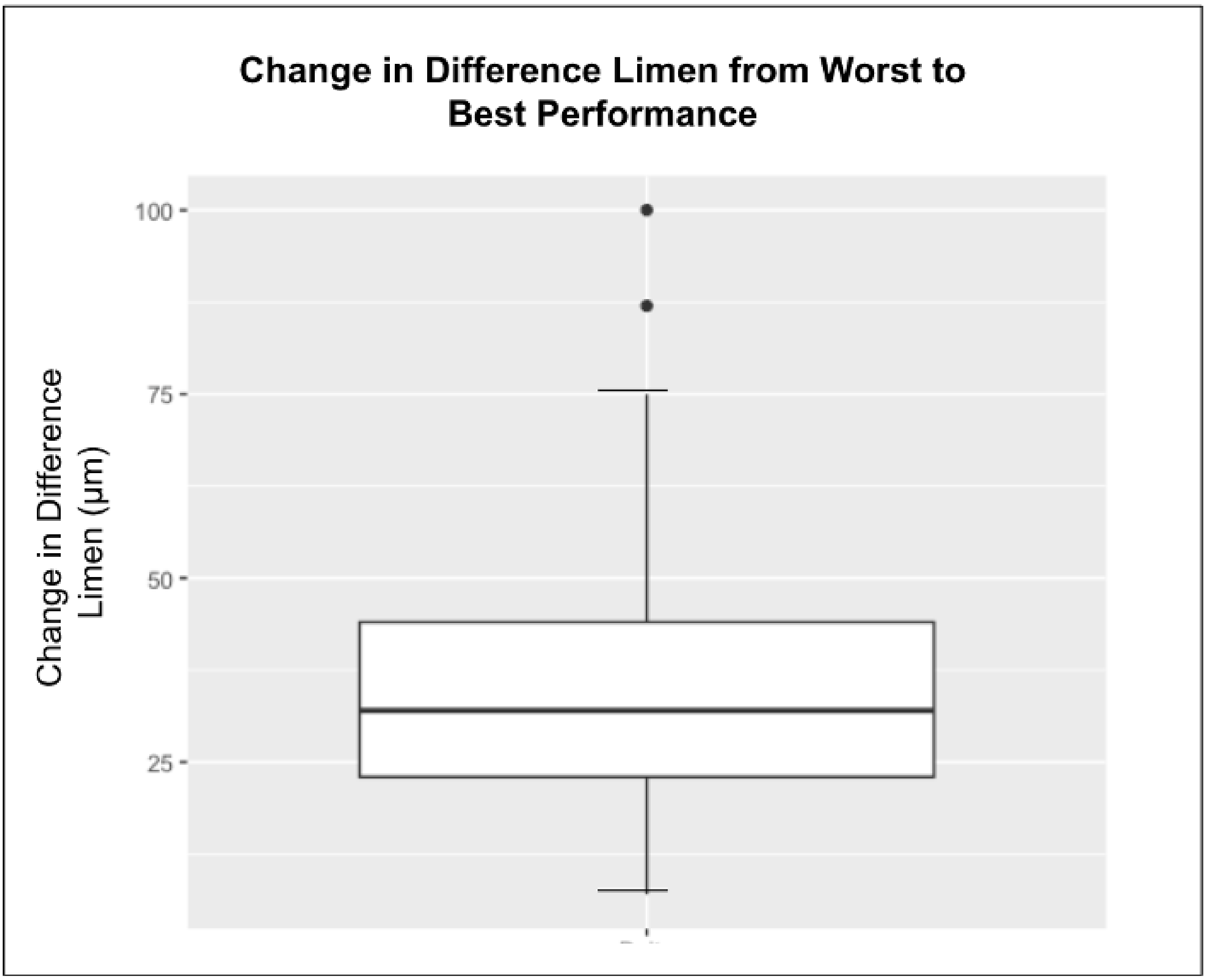

Figure 8. *Change in DL values and distribution.*

Survey Responses

Figure 9 displays a box and whisker plot of subject self-efficacy scores as compiled from the first survey. The mean self-efficacy score is 30.17, with a standard deviation of 3.47.

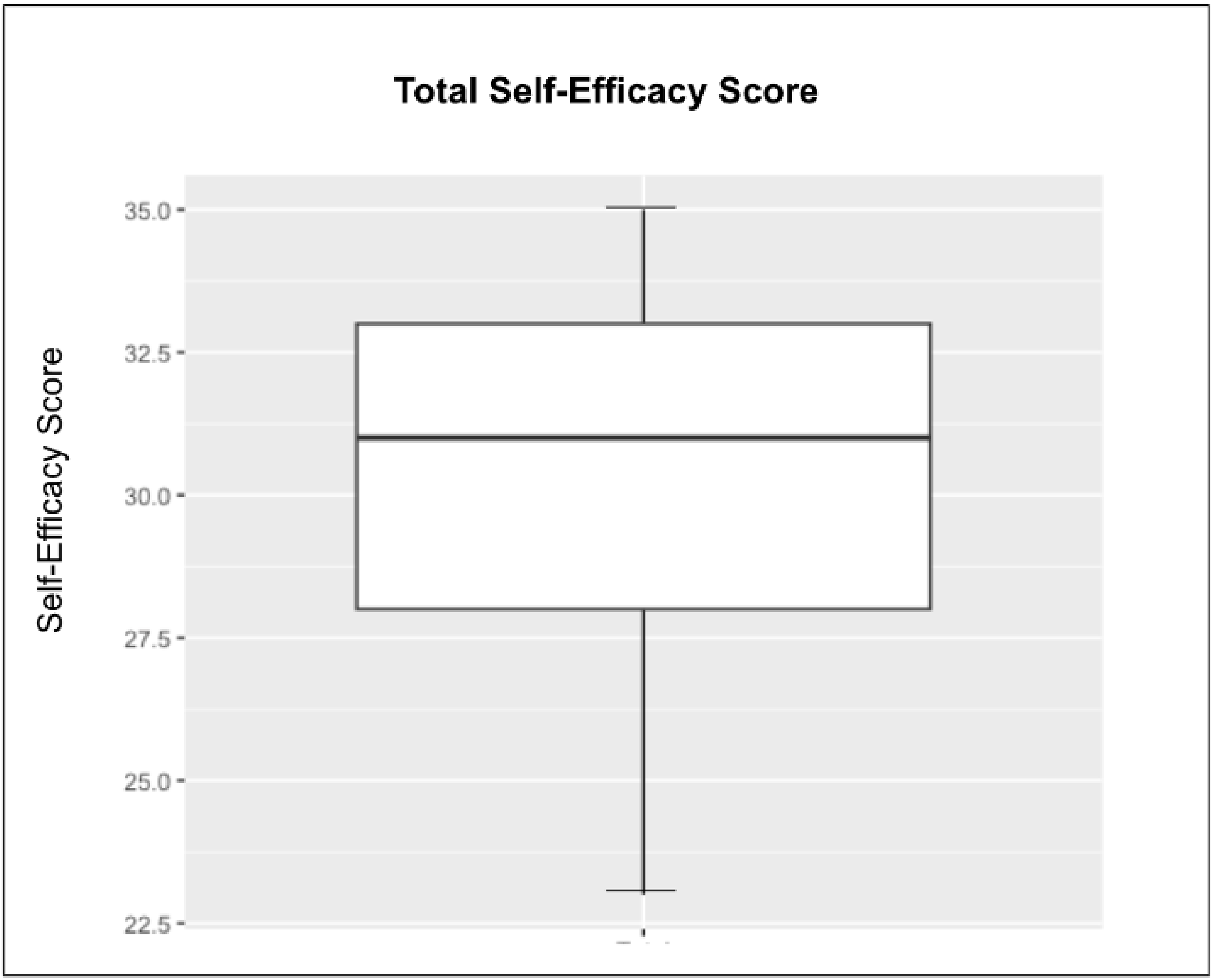

Figure 9. *Total self-efficacy score values and distribution.*

Figure 10, Figure 11, Figure 12, and Figure 13 contain twelve histograms that display the level of agreement of subjects with statements about their performance and perceptions of each feedback condition. Each of the figures display the statement they pertain to. Numerical values were assigned to levels of agreement such that a response of 5 indicated “strongly agree” and a response of 1 indicated “strongly disagree”.

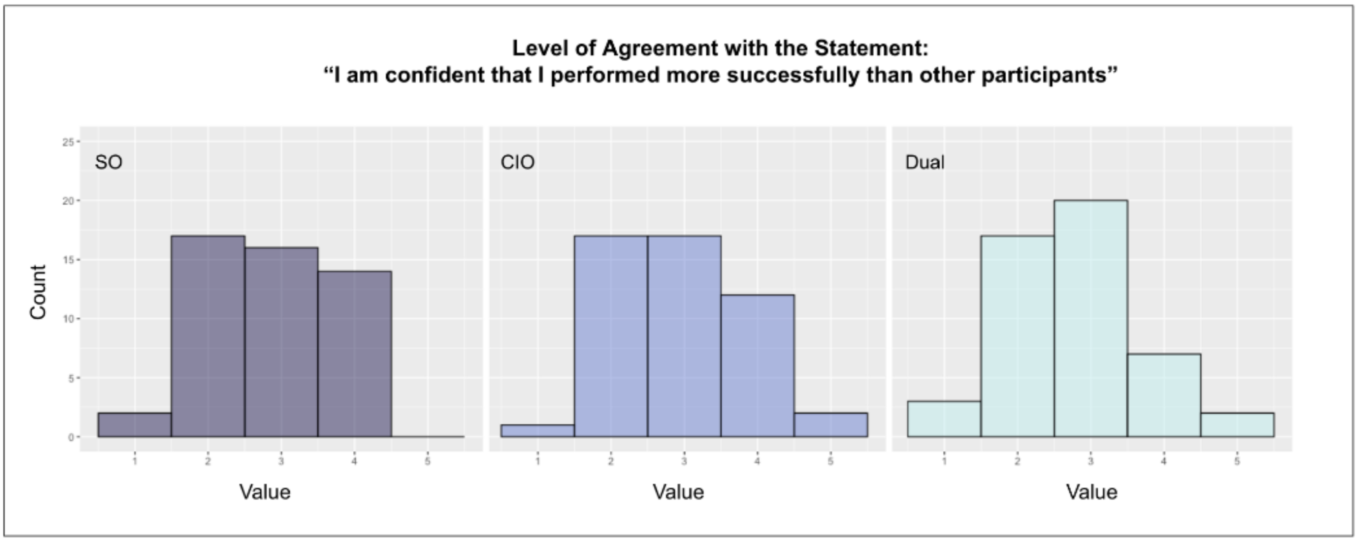

Figure 10. *Level of agreement with the statement provided. Feedback conditions are presented on three different graphs, with SO indicating the speed-only condition and CIO indicating the correct/incorrect-only condition.*

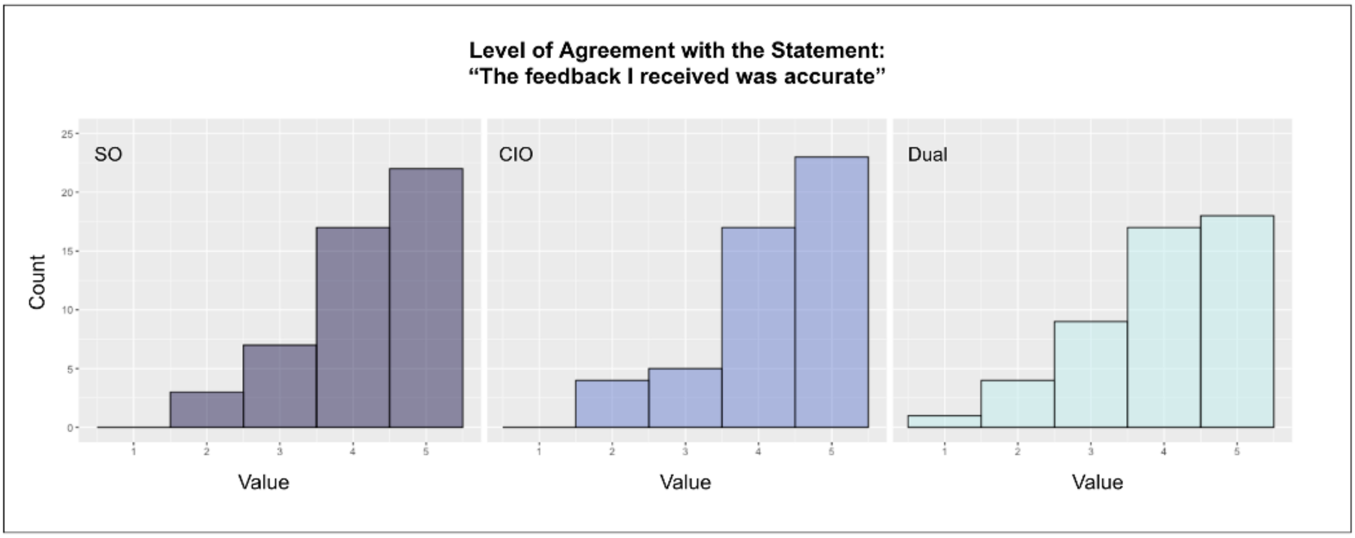

Figure 11. *Level of agreement with the statement provided. Feedback conditions are presented on three different graphs, with SO indicating the speed-only condition and CIO indicating the correct/incorrect-only condition.*

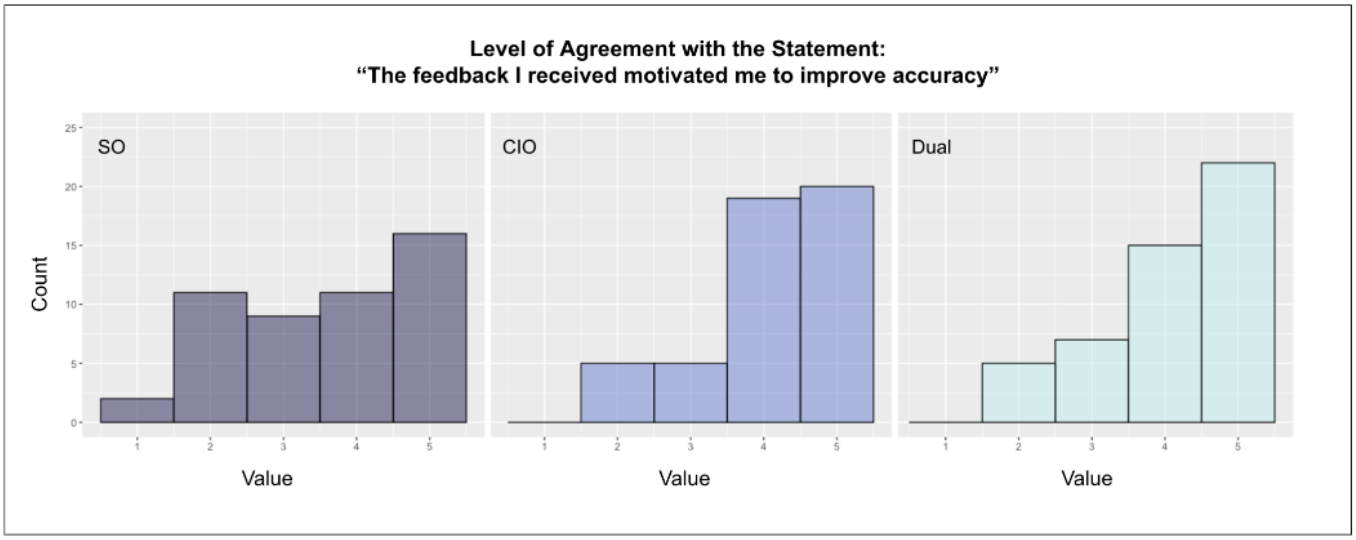

Figure 12. *Level of agreement with the statement provided. Feedback conditions are presented on three different graphs, with SO indicating the speed-only condition and CIO indicating the correct/incorrect-only condition.*

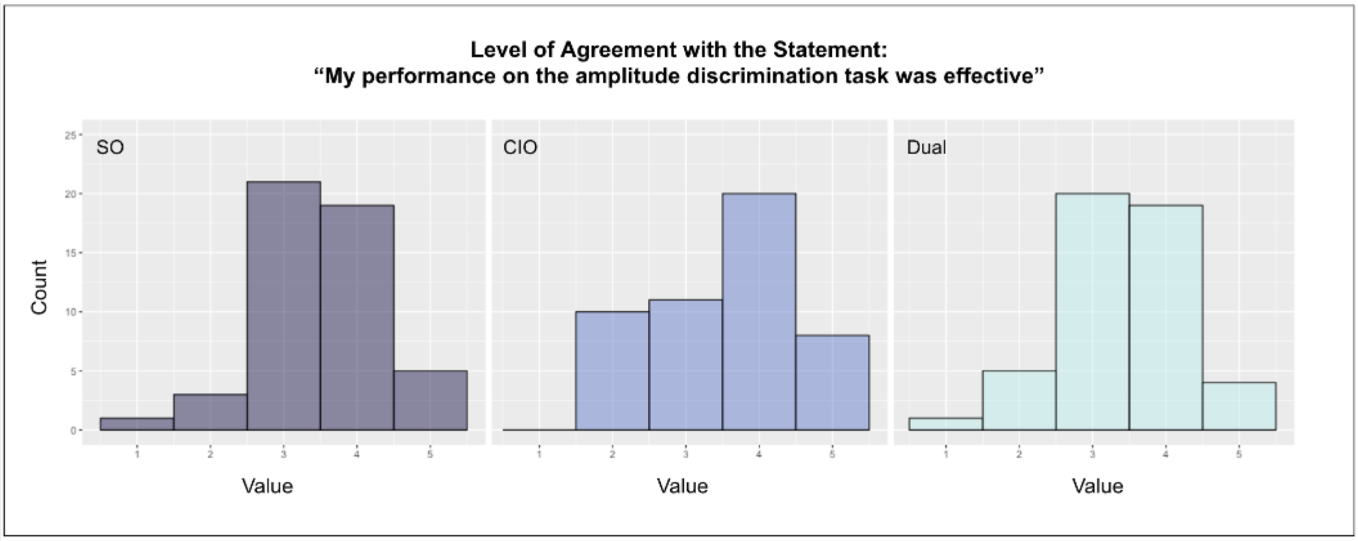

Figure 13. *Combination of Amplitude Discrimination and Survey Responses*

Combination of Amplitude Discrimination and Survey Responses

Figure 14 is a scatterplot of ΔDL versus self-efficacy scores from the first survey. The R^2 value of the line of best fit is 0.004, indicating there is a weak and negative, if any, correlation between the variables.

Figure 14. *Change in DL from worst to best score vs total self-efficacy score.* $R^2 = 0.004$.

Figure 15 shows self-efficacy scores split into two groups, the lower 50% of scorers on the self-efficacy survey and the upper 50% of scorers. The data was divided such that the ΔDL value for each person was categorized and averaged, and significance was determined via t-test.

	Lower 50%	Upper 50%
Mean ΔDL (μm)	42.43	28.17
Standard Deviation	24.96	11.52
p-value	0.03	

Figure 15. *Change in DL for lower 50% and upper 50% self-efficacy scorers. Significance in difference determined by two-tailed unpaired t-test.*

Discussion

The purpose of this study was to determine whether performance is impacted by the relationship between feedback and self-perception. Given the beneficial effects of feedback versus no feedback, and the potential for self-perception to play a role in performance, it was anticipated that there would be significant differences between types of feedback and the subjects' performance.

Contrary to the first hypothesis, results suggest that the presence of multiple forms of feedback did not produce enhanced performance as opposed to single feedback form conditions. Based on data represented in Figures 1, 2, 3, 4, 5 , the mean DL and RT showed no significant change between feedback conditions and demonstrated similar spread. This suggests that the type of feedback presented or the presence of multiple types of feedback does not have an impact on subject accuracy or speed when completing amplitude discrimination tasks. Although it was expected that the presence of more than one type of feedback would improve subject performance as in previous studies, this may not hold true for this type of task. However, this may also highlight the individualized nature of performance changes under different feedback conditions. Although averaging DL and RT for each feedback condition produces values which are unable to be distinguished from one another, this may suggest something different is at play rather than dismissing the notion that the different types of feedback made no difference in performance at all.

This is why the data was also organized to produce Figure 6 and 7. These counts of the best and worst performances for each participant organized underneath each feedback condition may assist in drawing conclusions about how performance changes as a result of changing feedback conditions. The highest number for best DL performance occurred with only correct/incorrect feedback. With this being the second condition, it is possible to attribute practice and fatigue to this finding. Figure 7 shows the highest number of best RT performance occurred under the dual feedback condition. These data indicate that there is a change in performance between feedback conditions. Figures 6 and 7 suggest that though it is likely that there are other stronger factors at play in whether feedback influences performance, there is still a visible difference in what conditions correlated with participants performing their best and worst.

In partial support of the second hypothesis, there is some evidence that subjects with lower self-efficacy scores were more prone to changes in their amplitude discrimination performance with changing feedback conditions. As shown in Table 6, the ΔDL value for subjects within the lowest 50% of self-efficacy scorers was significantly higher than both other groups. This indicates that this group had more variability in performance which may possibly be attributed to differences in feedback conditions. However, the low R^2 value of 0.004 when the ΔDL value was plotted against self-efficacy score in Figure 9 suggests that this relationship is not strongly linear or able to be fit to an equation in such a way that lower self-efficacy scores are associated with higher ΔDL values and vice versa. Therefore, it is reasonable to conclude that lower self-efficacy scores may correlate with greater variability in DL between feedback conditions and suggest that further studies are needed to solidify a relationship between these variables.

Lastly, the results provide support for the third hypothesis in that they demonstrate that subjects were more critical of their performance in the absence of the correct/incorrect feedback condition. Figures 11 and Figure 12 show a leftward skew in the speed-only feedback data from the other two feedback conditions. This indicates that participants felt less motivated and less confident in their performance for this feedback condition in particular. However, these perceptions were not accompanied by drastic changes in amplitude discrimination ability for most subjects. Therefore, it was not the performance itself but rather the type of feedback administered that caused subjects to feel this way about their performance.

Limitations in this study could have been introduced through experimental design. Because the dual feedback condition was tested after both single feedback conditions, practice and fatigue could have contributed to the measured DL and RT for each subject. These likely affected each subject in a different way, however randomization of order could prove to be beneficial in future iterations of this study. Additionally, each of the subjects had prior experience with the Brain Gauge and amplitude discrimination tasks. This also may have produced changes in results due to practice, yet this practice likely did not produce any discrepancies which would affect the results of this study in particular. There was no exclusion criteria for neurological disorders which could have had an effect on results. Most notably, each of the three conditions had a separate visual indication of correct or incorrect response on the screen. This created a third form of feedback which was present in all of the tested conditions and indicated accuracy during conditions which may have altered the results of the study. In the future, this could be changed to provide data that may yield different results and conclusions.

Conclusion

The primary finding from this study is there is a relationship between subject self-perception and responsivity to feedback. This is evidenced by the fact that there were performance changes between feedback conditions for individuals that were averaged to indicate no significant difference. Perceptions of performance in the presence of speed feedback only when a task requires accurate answers may not be as effective as providing reinforcement based on the subjects' accuracy itself. This may indicate that providing subjects with an indication of their accuracy may be more helpful both in their perceptions and performance itself.

Future studies should aim to decipher the nature of the relationship between self-perception and feedback and determine if there are characteristics of individuals that may serve as predictors of what type of feedback is most effective in enhancing performance.

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