The Relation between High-School Students' Performance and Feedback Memory

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Abstract

This paper describes a study that explores the relation between high-school students' feedback choices, memory for these feedback choices, and task performance. Choices to seek confirmatory (positive) or critical (negative) feedback and to revise posters in a poster design task were collected from ninety-two students from a Western US high school via Posterlet, a computer game assessment. A week following the study, the students were asked to recall the feedback phrases they encountered in Posterlet. Results show that the choices to seek critical feedback and to revise correlate with poster performance and with the amount of critical feedback remembered. A closer examination of the feedback value revealed that students' choices to revise correlated with the amount of informative, rather than uninformative, feedback remembered. Implications of students' feedback choices on their performance and feedback memory are discussed.

1. Introduction

Educational approaches to feedback have been researched extensively and they have yielded inconsistent results [1, 2, 3]. For example, critical (negative) feedback improves performance under specific circumstances [4], but it can hinder performance in others [4, 5]. Moreover, it is not clear to what extent students read or pay attention to feedback regardless of the quality of the feedback that the instructors provide [6]. The proposed research draws on our previous work examining the effect of choosing critical feedback, showing that the more the students chose to seek critical feedback, the more they dwelled on feedback [7]. The current study presents a novel free-recall task designed to explore the relation between students' choices to seek feedback and to revise, their memory for feedback, and their task performance. To the best of our knowledge, the current study is the first exploration of the relation between students' feedback valence choices and students' feedback memory. The study poses the following research questions:

1) Do choices to seek feedback and to revise correlate with the feedback remembered?

2) Do choices to seek feedback and to revise correlate with the informative or uninformative feedback remembered?

3) Does poster performance correlate with the choices to seek negative feedback and to revise, and with the memory for feedback?

The remainder of this paper reviews the literature relevant to the study, it describes the Posterlet assessment instrument that collects students' feedback and revision choices during a poster design task, and it presents empirical evidence that memory for critical informative feedback is associated with performance and with the choices to revise and to seek critical feedback.

2. Literature Review

Choice-Based Assessments. Traditional assessments focus on students' outcome accuracy at a given point in time, but they do not provide an insight into how prepared students are to learn on their own and to perform well on new tasks. In contrast, choice-based assessments [8], which stem from constructivist assessments [9], focus on the learning processes in which students engage while solving a new challenge. These types of novel assessments offer a glimpse into how prepared students are to learn on their own. This paper examines, for the first time, students' choices collected using a choice-based assessment game. In contrast to our previous research that focused on validating choices as predictors of independent learning outside of the assessment environment, the current research aims to understand more about the mechanism of feedback processing and, thus, it focuses on students' memory for the feedback valence they freely choose.

Feedback Memory. Selective memory for feedback is a strategy individuals employ to cope with self-threatening feedback (i.e., feedback that accurately highlights one's weaknesses), likely as an effect of self-protection motivation. For example, the mnemic neglect effect [10] is defined as inferior

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recall for self-threatening feedback compared to other types of feedback (e.g., self-affirming feedback or feedback that highlights one's strengths). However, this effect is attenuated if the feedback is perceived as referring to modifiable traits, when it can trigger self-improvement motivation [11, 12, 13]. In this paper, the critical feedback students choose is constructive and not punishing. Thus, this research hypothesizes that students will remember this type of feedback well. Another individual characteristic that is known to affect feedback processing is a learner's limited working memory capacity, which constitutes the ability to concomitantly store and process information. Thus, the learner must process the feedback information while drawing from prior knowledge stored in long-term memory [14]. A limited working memory implies a limited ability to decode or to make sense of the feedback in the context of a specific task [15].

Feedback Memory and Performance. Research on the neural correlates of learning provides evidence that neural responses to feedback can predict future performance. Specifically, the brain responses to feedback are predictive of whether university students will repeat mistakes or will learn from their mistakes [16]. In this paper, the relation between students' memory for critical feedback and their subsequent performance is explored for a high-school population.

Feedback and Dwell Time. In our prior research, we found that the more the students chose critical feedback, the more they dwelled on their chosen feedback messages [7]. This may indicate that students pay more attention to critical feedback than to confirmatory feedback. An eye-tracking study focused on help behaviors revealed that students with a positive attitude towards help also dwelled more on the help messages [17]. This indicates that students' attitudes toward self-improvement may play an important role in their engagement with feedback. However, our previous studies showed that any student, not just a student already employing good learning strategies, who chose more critical feedback from one round to the next, also spent more time reading feedback from one game round to the next. In this paper, the relation between students' memory for critical feedback and the time they take to read their feedback is explored.

3. The Posterlet Assessment Game

The Posterlet choice-based assessment game was designed to collect and assess two learning choices students made while they were designing posters: the choice to seek confirmatory (positive) and critical (negative) feedback about their posters and the choice to revise or not their posters after choosing feedback from three virtual characters on each poster. Students played three rounds of the Postelet game. On each round, students chose either confirmatory (i.e., *I like*) or critical (i.e., *I don't like*) feedback from each of the three virtual animal characters, as shown in Figure 1.

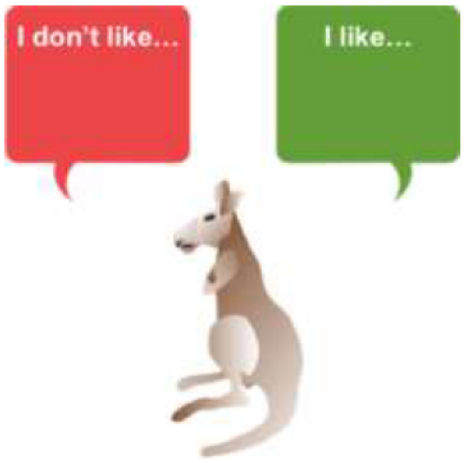

Figure 1. After designing a poster, students choose between confirmatory and critical feedback from three characters in Posterlet

Then, students chose whether to revise their poster or not. The feedback messages generated by the game alternated between informative (confirmatory: "Your poster helps people know where to go." or critical: "Where is the Fall Fair going to be?") and uninformative (confirmatory: "I like fairs" or critical "I don't like fairs."). The Posterlet assessment instrument is described in detail in our prior work [7].

On each round, the game tracks the number of critical feedback choices, as well as the number of revision choices made by the student. These measures are employed to quantify students' learning choices in the game. Additionally, the game analyzes each poster and produces a poster score displayed to the students as the number of tickets sold by their poster booth after the final version of the poster is submitted. This measure is employed to quantify the students' poster performance (i.e., it reflects how many graphic design rules students used correctly versus incorrectly on each poster).

4. Methods

4.1. Participants and Procedures

Participants are ninety-two students, ranging from grade 9 to 12, from a public high school in a Western United States mid-sized city. The testing activity took place in students' regular classrooms, as one of several assessments administered that day. Students designed three posters in the Posterlet game (M=8.12 minutes, SD=3.82) individually. Most students completed at least two rounds of the three-round Posterlet game. Then, after a week, students

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filled a feedback memory survey individually. An example of a student's answers to the memory survey is shown in Figure 2.

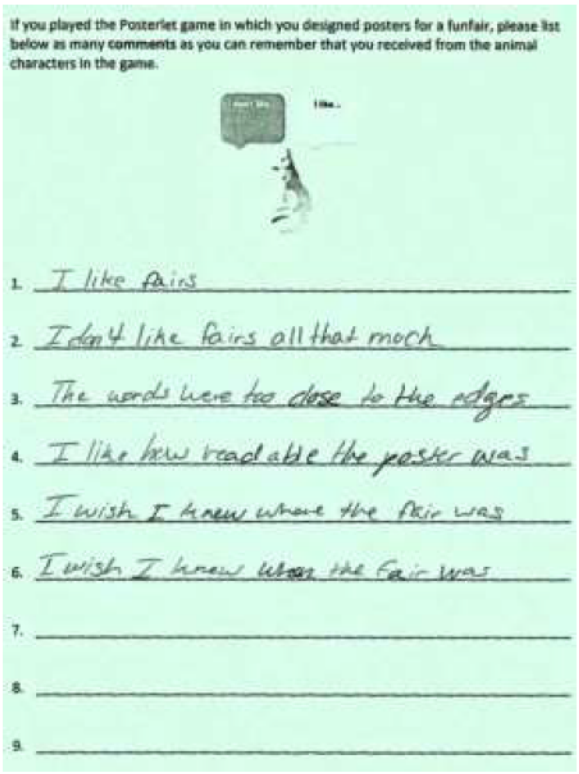

Figure 2. A student's responses to the feedback memory survey

4.2. Measures

4.2.1. Choices. *Critical Feedback* measures the number of "I don't like…" choices made by the student, ranging from 0 (the student chose only confirmatory feedback across the game) to 9 (the student chose only critical feedback across the game). *Revision* measures the number of posters a student chose to revise, ranging from 0 (the student chose to never revise posters across the game) to 3 (the student chose to revise all three posters). As well, the informative (*Critical Informative Feedback*) and uninformative (*Critical Uninformative Feedback*) components of feedback were tracked. The *Confirmatory Feedback* measure is complementary to the Critical Feedback measure. Specifically, on each game round, a student makes three choices between either confirmatory or critical feedback. Therefore, across the game, *Confirmatory Feedback* is computed as 9 minus *Critical Feedback*. Thus, all direct correlations with *Critical Feedback* constitute inverse correlations with *Confirmatory Feedback*.

4.2.2. In-game Poster Performance. Posterlet generates a *Poster Quality* score based on 21 design principles reflecting a student's performance across all rounds of the game. The quality of each poster is the sum of the scores for each of the 21 features: 1 if a feature is always used correctly on a poster, 0 if a feature is not included on the poster, and -1 if a feature is used incorrectly on a poster. *Poster Quality* measures the sum of each of the three posters' quality. The first round of the game was treated as exploratory. For some analyses, a new measure, *Poster Quality 2&3*, was created that restricted Poster Quality to the last two rounds of the game. This measure constitutes the sum of the poster quality across the last two rounds of the game. It was computed to provide a better sense of students' behaviors, because the first round of the game was exploratory, the game lacking a separate tutorial.

4.2.3. Memory for Feedback. *Critical Feedback Remembered* measures the number of critical feedback messages remembered by the student. The paper differentiates further between *Critical Informative Feedback Remembered* (e.g., specific information that was incorrect or missing on the poster, such as small-size text used on the poster) and *Critical Uninformative Feedback Remembered* (e.g., "I don't like fairs"). The *Critical Feedback Remembered* measure represents the sum of these two measures. Equivalent measures for confirmatory feedback were collected: *Confirmatory Feedback Remembered* constitutes the sum of *Confirmatory Informative Feedback Remembered* (e.g., specific information that was correct on the poster, such as a large font-size text used on the poster) and *Confirmatory Uninformative Feedback Remembered* (e.g., "I like fairs"). Finally, the *Total Feedback Remembered* measured the sum of the *Critical Feedback Remembered* and *Confirmatory Feedback Remembered*. For example, in Figure 2, the student's answers represent different types of feedback remembered: 1 (i.e., "I like fairs") is confirmatory uninformative, 2 is critical uninformative, 3, 5, and 6 are critical informative, and 4 is confirmatory informative. The score for each of these four categories represented the count of the answers in that category. For example, this student's scores were the following: critical informative feedback remembered = 3, critical uninformative feedback remembered = 1, confirmatory informative feedback remembered = 1, and confirmatory uninformative feedback remembered = 1.

4.2.4. Time on Task. *Design Duration* measures the amount of time students spent designing their posters. *Feedback Duration* measures the amount of time students spent dwelling on their feedback (i.e., reading the feedback).

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5. Results

5.1. Do choices to seek feedback and to revise correlate with the feedback remembered?

Spearman correlations were conducted to answer this question, because the measures included in these analyses were not normally distributed. Table 1 shows the correlations between the Posterlet measures and the amount of feedback (critical, confirmatory, and combined) remembered. Both choices (*Critical Feedback* and *Revision*) correlate with the critical feedback remembered. Moreover, the choice to seek critical feedback correlates with the total amount of feedback remembered. There is no association between *Critical Feedback* and *Confirmatory Feedback Remembered*. Consequently, there is no association between *Confirmatory Feedback* and *Confirmatory Feedback Remembered*, since *Confirmatory Feedback* is a complementary measure of *Critical Feedback*.

Table 1. Correlations between choices and measures of the memory for feedback

Choice (n=89)	Cr. Fb. Rem.	Cf. Fb. Rem.	Total Fb. Rem.
Cr. Fb.	**.58****	-.15	**.32****
Revision	**.24***	.05	.17

Note: $^{**}p<.01$, $^{*}p<.05$, Cr.: Critical, Cf.: Confirmatory, Fb.: Feedback, Rem.: Remembered.

Consistent with the findings of our previous research [7], Negative Feedback and Revision were also correlated (*rho* = .46, $p < .001$). Next, the analyses examined whether Negative Feedback and Revision were independent predictors of the critical feedback remembered. Thus, both choices were entered in a linear standard regression. Results show that the model was significant [$F(2, 89) = 20.99$, $p < .001$, R Square = .32, and Adjusted R Square = .30] and that Critical Feedback was a significant predictor [$t(89) = 6.20$, $p < .001$] of *Critical Feedback Remembered*, but that Revision was not a significant predictor of *Critical Feedback Remembered* [$t(89) = -1.13$, $p = .26$].

5.2. Do choices to seek feedback and to revise correlate with the informative or uninformative feedback remembered?

Results indicate that *Critical Feedback* correlated with both measures of critical feedback remembered: *Critical Informative Feedback Remembered* and *Critical Uninformative Feedback Remembered*, as shown in Table 2. Revision only correlated with *Critical Informative Feedback Remembered*.

Table 2. Correlations between choices and feedback memory measures, by informative and uninformative feedback value

Choice (n=89)	Cr. I. Rem.	Cr. U. Rem.	Cf. I. Rem.	Cf. U. Rem.
Crit. Fb.	**.57****	**.32****	-.11	-.08
Revision	**.23***	.10	.11	-.10

Note: $^{**}p<.01$, $^{*}p<.05$, Cr.: Critical, I.: Informative, U: Uninformative, Cf.: Confirmatory, Rem: Remembered.

5.3. Does poster performance correlate with the choices to seek negative feedback and to revise, and with the memory for feedback?

Performance and Other In-game Measures. First, the study investigated whether the in-game measures (poster performance, design duration, and feedback duration) were correlated with the choices to seek negative feedback and to revise. The Spearman correlations of the measures are presented in Table 3. Results show that students' poster performance (*Poster Quality*) correlates with both choices (*Critical Feedback* and *Revision*), which is consistent with our previous research. Also, the time students spent designing posters (*Design Duration*) correlated with *Revision* and with *Poster Quality*. Finally, the time students dwelled on feedback (*Feedback Duration*) correlated with the critical feedback chosen and with the time students spent designing posters.

Table 3. Correlations of in-game measures

Measure (n=89)	PQ	DD	FD
Critical Feedback	**.25***	.17	**.23***
Revision	**.25***	**.21***	.09
Poster Quality	--	**.37****	.15
Design Duration	--	--	**.38****

Note: $^{**}p<.01$, $^{*}p<.05$, PQ: Poster Quality, DD: Design Duration, FD: Feedback Duration.

Performance and Memory for Feedback. The next analyses investigated whether the in-game measures (poster performance, design duration, and feedback duration) were associated with students' four different types of memory for feedback, according to the valence and informative value of the feedback. Spearman correlations between the measures and the memory for feedback are presented in Table 4. Results indicate that Design Duration correlated with both the critical informative and confirmatory informative feedback remembered. Although results show a positive correlation between Feedback Duration and Critical Feedback, no association was found between dwelling on feedback and memory for confirmatory or critical feedback.

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Table 4. Correlations between in-game measures and feedback memory measures

Measure (n=89)	Cr. I. Rem.	Cr. U. Rem.	Cf. I. Rem.	Cf. U. Rem.
PQ	.20	.11	-.01	.12
DD	**.21***	.20	**.22***	.09
FD	.19	.11	.01	-.07

Note: *$p<.05$, PQ: Poster Quality, DD: Design Duration, FD: Feedback Duration, Cr.: Critical, Cf.: Confirmatory, I.: Informative, U.: Uninformative, Rem.: Remembered.

Finally, the association of performance, choices (seeking feedback and revising), and memory of feedback on the last two rounds of the game was further explored. Specifically, only the last two round of the game were considered in the analyses, because the game lacked a tutorial and students used the first game round to explore the features available in the game. Standard linear regression analyses were conducted to investigate whether students' performance on the last two rounds of the game provided any insights into the type of feedback students remembered. Results yielded that *Poster Quality 2&3* (the poster performance on the last two rounds of the game) predicted *Critical Feedback Remembered* [$t(90) = 2.21$, $p = .03$; $F(1, 90) = 4.89$, R Square = .05, Adjusted R Square = .04], but it did not predict *Confirmatory Feedback Remembered* [$t(90) = -.49$, $p = .62$; $F(1, 90) = .24$, R Square = .003, Adjusted R Square = -.008]. More specifically, *Poster Quality 2&3* predicted *Critical Informative Feedback Remembered* [$t(90) = 2.34$, $p = .02$; $F(1, 90) = 5.47$, R Square = .06, Adjusted R Square = .05], but it did not predict *Critical Uninformative Feedback Remembered* [$t(90) = .94$, $p = .35$; $F(1, 90) = .41$, R Square = .01, Adjusted R Square = -.001].

6. Discussion

Choices and Memory. Results revealed that the more the students chose to seek critical (negative) feedback and to revise, the more feedback they remembered overall. Specifically, when the valence of the feedback remembered was examined, results showed that the more the students chose to seek critical feedback and to revise, the more they remembered critical feedback. Conversely, the more the students chose to seek confirmatory (positive) feedback (which is the complementary measure of choosing critical feedback), the less they remembered critical feedback. Moreover, of the two choices (to seek critical feedback and to revise), only seeking critical feedback predicted the amount of critical feedback remembered by the student. This result indicates that the choice to seek feedback is more important than the choice to revise for feedback memory. Next, the study aimed to discern between the impact of informative and uninformative value of critical feedback on feedback memory.

Feedback Value and Memory. Results show that the more the students chose critical feedback, the more critical informative and uninformative feedback they remembered. However, the more the students chose to revise, the better their memory for critical informative, not uninformative, feedback. This result indicates that informative feedback is more important than uninformative feedback for driving revision. Conversely, the choice to seek confirmatory feedback inversely correlated with both the informative and the uninformative critical feedback remembered, but it did not correlate with any of the types (informative and uninformative) of confirmatory feedback remembered. Thus, the more the students sought confirmatory feedback, the less they remembered critical informative and uninformative feedback, without improving their memory for confirmatory feedback. This indicates that choosing critical feedback has a more lasting effect on memory for feedback than choosing confirmatory feedback. Next, in a follow-up analysis, the association between critical informative feedback and performance was explored.

Performance, Choices, and Feedback Memory. Consistent with prior research, poster performance correlates with both choices to seek critical feedback and to revise [7]. Regarding feedback memory, on the combined last two rounds of the game, poster performance predicts students' memory for critical informative feedback. This result indicates that the better the students perform on the poster design task, the better they remember the critical feedback that they chose in the game.

Time on Task and Feedback Memory. The time students spent designing posters correlated with Revision and Poster Quality, consistent with prior research [7]. Also, the time students dwelled on feedback correlated with their choice of critical feedback and with the time students spent designing posters. In terms of feedback memory, the time students spent designing posters correlated with both the critical informative and confirmatory informative feedback they remembered. The time students dwelled on feedback did not correlate with their memory for feedback. This situation may be due to considering the first round of the game in the analyses. In the future, a more detailed analysis will be conducted by linking the remembered feedback to each game round and by limiting the analyses to the last two rounds of the game, when students had already settled on a learning strategy.

7. Conclusions

The paper provides an insight into feedback processing and recall by examining students' memory for the feedback they choose, following data

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collection of their learning choices via a choice-based assessment game, Posterlet, designed to track students' choices between confirmatory and critical feedback. The data provide evidence that choosing critical feedback is associated with better memory for critical feedback. This research has implications for the design of assessment environments that can help students engage more closely with feedback, remember the feedback content better, and, consequently, apply it to improve their performance.

8. Future Work

The relation between the valence (i.e., confirmatory or critical) of the feedback sought by students and their memory for critical and confirmatory feedback was explored. In the future, a follow-up study will explore whether students remember critical and confirmatory feedback differentially when they receive (i.e., when they are assigned), rather than choose, their feedback. The study will also explore whether there are any associations between the feedback valence students remember the most and other measures (e.g., academic achievement or mindset).

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