THE IMPACT OF MIDDLE-SCHOOL STUDENTS' FEEDBACK CHOICES AND PERFORMANCE ON THEIR FEEDBACK MEMORY

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ABSTRACT

This paper presents a novel examination of the impact of students' feedback choices and performance on their feedback memory. An empirical study was designed to collect the choices to seek critical feedback from a hundred and six Grade 8 middle-school students via Posterlet, a digital assessment game in which students design posters. Upon completing the game, students filled a survey asking them to recall the feedback phrases they encountered in Posterlet. Results show that choosing critical feedback correlated with the critical feedback students remembered. Additionally, choosing critical feedback and poster performance inversely correlated with the confirmatory feedback students remembered. A closer examination of the informational value of feedback revealed that choosing critical feedback correlated with both types (i.e., informative and uninformative) of critical feedback remembered and it inversely correlated with both types of confirmatory feedback remembered. Finally, poster performance correlated with the critical uninformative feedback remembered and inversely correlated with the confirmatory uninformative feedback remembered. Ramifications for students' learning performance are discussed.

KEYWORDS

Feedback, Memory, Assessment, Game, Revision, Learning Performance

1. INTRODUCTION

In educational settings, feedback generally improves performance (Hattie and Timperley, 2007). However, a meta-analysis found that feedback hindered performance in a third of the studies examined (Kluger and DeNisi, 1998). There are many reasons for this discrepancy. For example, task-directed feedback seems to be more helpful than person-directed feedback, such as praise or punishment unrelated to the task (Black and William, 1998; Hattie and Timperley, 2007). Moreover, although the quality of the learners' engagement with feedback is believed to be a determinant factor of feedback effectiveness (Winstone et al., 2016), few studies examine this aspect of feedback (Bounds et al., 2013). Instead of focusing on feedback that is assigned to the learner, this paper examines the mechanisms that unfold when students engage proactively with feedback by choosing between confirmatory (positive) and critical (negative) feedback. There is a paucity of research examining the effectiveness of feedback seeking (Evans, 2013) and the impact of feedback on students' memory, especially when students choose the valence of their feedback. This paper focuses for the first time on the lasting impact of choices between confirmatory and critical feedback on students' memory for feedback. It also examines the role that learning performance plays in the context of feedback choices and memory. Building on research that validated choices as predictors of learning performance (Cutumisu et al., 2015), this paper aims to gain an insight into the mechanisms of feedback processing by focusing on choices as predictors of students' memory for feedback and it hypothesizes that students' learning choices and performance reveal important insights into students' critical feedback remembered from the game. The current study employs Posterlet, an assessment game, together with a free-recall task administered immediately after the game, to examine the impact of feedback choices and performance on students' memory for feedback and it poses the following research questions:

1. Do in-game measures correlate with students' memory for critical feedback?

2. Do in-game measures correlate with students' memory for critical informative feedback?

3. Does in-school performance correlate with students' memory for critical informative feedback?

First, the paper reviews the literature relevant to this study. Second, it describes a) the Posterlet assessment instrument, a game that collects students' feedback choices while students design posters, and b) the feedback memory survey that collects students' feedback phrases recalled after playing the Posterlet game. Third, it presents empirical evidence addressing the research questions. Finally, it concludes with a discussion of the implications, limitations, and future research directions.

2. LITERATURE REVIEW

This section relates the study to the relevant literature on choice-based assessments, feedback memory, and the relation between performance and feedback memory.

Choice-based assessments. Educators aim to support learners in developing 21st-century skills that will prepare them to tackle complex problems (e.g., rapidly-spreading diseases). In 2012, the *Programme for International Student Assessment* (PISA) introduced items that collected information about students' attitudes towards problem solving for the first time since it started administering tests in 2000 (OECD, 2016). This trend is due in part to the focus of traditional assessments on outcome accuracy, rather than on the preparedness of students to perform well on new tasks. In contrast, choice-based assessments focus on the learning processes in which students engage when solving a new challenge (Schwartz and Arena, 2013). These types of novel assessments offer a glimpse into how prepared students are to learn on their own. Examining feedback choices that enable students to play an active role in their learning is also important from the perspective of self-regulated learning. Butler and Winne (1995) emphasized that, by engaging proactively with their feedback, learners can develop effective self-assessment skills that enable them to better appraise their own performance (McDonnell and Curtis, 2014; Wakefield et al., 2014). In this study, Posterlet is employed to collect and measure students' proactive choices to seek feedback and to revise as a way to capture their preparedness to learn on their own.

Feedback memory. Students adopt many strategies to cope with self-threatening feedback that accurately highlights their weaknesses. For instance, they display an inferior recall for such feedback compared to other types of feedback (e.g., self-affirming feedback that highlights one's strengths). The theory of mnemic neglect posits that such an effect is attenuated, triggering self-improvement motivation (Dauenheimer et al., 2002; Green et al., 2005; Roese and Olson, 2007; Sedikides et al., 2016), when feedback is perceived as referring to modifiable traits. In this research, critical feedback is constructive and not punishing, and students exercise a choice regarding their feedback valence. Thus, the paper hypothesizes that students will remember, and not suppress, the critical feedback they chose.

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 (van der Helden et al., 2010). In contrast, this paper explores the relation between students' performance and their subsequent memory for critical feedback and it examines a different population (i.e., middle-school students).

3. THE ASSESSMENT GAME AND THE MEMORY SURVEY

This section presents 1) Posterlet, the assessment instrument that collects students' choices to seek critical feedback and to revise and 2) the feedback memory survey devised to collect the feedback phrases students recall after playing the game.

3.1 Posterlet

The Posterlet game enables students to design a poster on each of the game's three rounds and to perform two main choices at the end of each poster design task. Upon completing each poster, students choose either confirmatory (e.g., *It's good you told them what day the fair is.*) or critical (e.g., *People need to be able to*

read it. Some of your words are too small.) feedback from three animal characters, as shown in Figure **1**. After reading the feedback, students choose whether to revise that poster. Posterlet, described in detail in previous work (Cutumisu et al., 2015), tracks these two choices (seeking critical feedback and revising) and computes a poster score per poster round, as well as a cumulative poster score per game.

Figure 1. In the Posterlet game, the students design posters and choose either confirmatory or critical feedback

3.2 Memory Survey

Immediately following the game, students were automatically directed to an online survey, where they were asked to recall as many feedback comments as they remembered from the Posterlet game, out of a maximum of nine (i.e., there are three opportunities to choose feedback for each of the three game rounds). Students were provided with the following prompt and a screenshot from the game, as illustrated below: *If you played the Posterlet game in which you designed posters for a funfair, please list below as many* ***comments*** *as you can remember that you received from the animal characters in the game.*

Figure 2. The memory survey asking students to recall their feedback after playing Posterlet

Feedback alternated between informative and uninformative phrases exemplified in *Section 4.2.4* to avoid cognitive load for younger participants. The example presented in Table 1 of a student's survey answers and scores shows that, of the seven feedback phrases the student remembered, four were critical (two informative and two uninformative), while three were confirmatory (all informative).

ISBN: 978-989-8533-55-5 © 2016

Table 1. A sample of a student's answers and scoring for the memory survey. The student did not provide answers for items 8 and 9, so these answers were scored with zero. Note: Crit. = Critical, Inf. = Informative, Uninf. = Uninformative

Order	Feedback Remembered	Crit. Inf.	Crit. Uninf.	Conf. Inf.	Conf. Uninf.	Crit. Total	Conf. Total	Total
1	I don't like fairs	0	1	0	0	1	0	1
2	I like that the text does not cut off the page	0	0	1	0	0	1	1
3	I don't really go to fairs	0	1	0	0	1	0	1
4	I don't like that the text is too close together	1	0	0	0	1	0	1
5	I don't like that it doesn't have the admissions price	1	0	0	0	1	0	1
6	I like that is has the date and time	0	0	1	0	0	1	1
7	I like that it has the location	0	0	1	0	0	1	1
8	-	0	0	0	0	0	0	0
9	-	0	0	0	0	0	0	0
Total		**2**	**2**	**3**	**0**	**4**	**3**	**7**

4. METHODS

4.1 Participants and Procedure

Participants were n=106 (60 females) Grade 8 students, aged 13-14, from a public middle school in California. All students played Posterlet and n=86 of them filled an online memory survey immediately after playing the game in May 2015. Students designed three posters (M=14.76 minutes, SD=4.07) individually, as one of several assessments administered that day. Due to time constraints, a post-test to measure students' learning of graphic design principles was not administered. Upon completing the game, students filled a feedback memory survey. Students who did not provide consent (n=9) or did not complete all posters (n=8) were excluded from analyses. Thus, the analyses comprise n=89 students (50 females). Some of the students did not complete the survey due to time constraints, some parents did not provide consent for sharing their children's standardized test scores, so students were removed from the analyses as needed.

4.2 Measures

4.2.1 Choices

Critical Feedback measures the total amount of critical (*I don't like…*) feedback a student chose, ranging from zero (i.e., the student chose confirmatory feedback throughout the game) to nine (i.e., the student chose critical feedback across the game). Revision measures the total number of posters a student chose to revise, ranging from zero (i.e., the student did not revise any poster) to three (i.e., the student revised all posters).

4.2.2 In-Game Performance

As mentioned before, Posterlet computes a Poster Quality score based on 21 design principles reflecting a student's performance across 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 sums the poster quality of all three posters.

4.2.3 In-School Performance

STAR (Standardized Testing and Reporting) scores indicating students' achievement outside the game were obtained from the school for a subset of students. They included scores in English Language Arts (ELA-CST) and Mathematics (Math-CST) recorded two years prior to conducting this study, when students were in Grade 6. These were the last available standardized tests before the transition to the Common Core tests.

4.2.4 Memory Survey Measures

Critical Feedback Remembered measures the number of critical feedback phrases a student recalled. Further, *Critical Informative Feedback Remembered* measures the amount of informative critical feedback phrases (e.g., *People need to be able to read it. Some of your words are too small.*) that the student recalled, while *Critical Uninformative Feedback Remembered* measures the amount of uninformative critical feedback phrases (e.g., *I don't like fairs*) that the student recalled. *Critical Feedback Remembered* constitutes the sum of these two measures. Similar measures were used for confirmatory feedback. *Total Feedback Remembered* constitutes the sum of *Critical Feedback Remembered* and *Confirmatory Feedback Remembered*.

5. DATA ANALYSES AND RESULTS

5.1 Do In-Game Measures Correlate with Students' Memory for Critical Feedback?

These analyses tested the hypothesis that students' choices and performance correlated with students' memory for critical, rather than confirmatory, feedback choices. The impact of students' choices and performance on feedback memory was investigated using Spearman rank correlations (*rho*), because these measures were not normally distributed. Thus, correlations were conducted between students' in-game measures (choices measured by Critical Feedback and Revision, and poster performance measured by Poster Quality) and survey measures (the feedback that the students remembered, such as critical, confirmatory, and total). Results presented in Table 2 show that Critical Feedback strongly correlated with the critical, and inversely with the confirmatory, feedback that the students remembered. Results show a similar pattern for Revision, but with moderate correlations. Finally, poster performance inversely correlated with the confirmatory feedback remembered. Thus, critical feedback remembered correlated significantly with both in-game choices and non-significantly with in-game performance.

Table 2. Spearman correlations between choices and measures of memory for feedback ($^{**}p < .01$, $^{*}p < .05$)

Measures (n = 73)	Critical Feedback Remembered	Confirmatory Feedback Remembered	Total Feedback Remembered
Critical Feedback	**.58****	**-.58****	.11
Revision	**.26***	**-.29***	-.05
Poster Quality	.16	**-.24***	-.09

Next, two linear standard regressions examined whether the strongly correlated (*rho* = .40, $p < .01$) choices (Negative Feedback and Revision) were independent predictors of each of the types of feedback remembered, to determine which choice is more important for feedback memory. A regression analysis was not conducted for Total Feedback Remembered, because it was not associated with any of the choices. Choices were entered as predictors of Critical Feedback Remembered and Confirmatory Feedback Remembered, respectively. Results showed that the model predicting Critical Feedback Remembered was significant [$F(2, 70) = 14.45$, $p < .001$, R Square = .29, Adjusted R Square = .27] and Critical Feedback was a significant predictor [$t(72) = 4.87$, $p < .001$], but Revision was not [$t(72) = .37$, $p = .71$]. The same pattern of results emerged for the model predicting Confirmatory Feedback Remembered [$F(2, 70) = 17.67$, $p < .001$, R Square = .34, Adjusted R Square = .32]: Critical Feedback was a predictor [$t(72) = -4.96$, $p < .001$], but Revision was not [$t(72) = -1.27$, $p = .21$]. Thus, the choice to seek critical feedback is more important for feedback memory than the choice to revise.

5.2 Do In-Game Measures Correlate With Students' Memory for Critical Informative Feedback?

These analyses tested the hypothesis that students' choices and performance correlated with their memory for critical informative feedback. Thus, the impact of the informational value of feedback on feedback memory was examined by conducting Spearman correlations between in-game measures (choices to seek critical

feedback and to revise, as well as performance) and feedback memory. The latter was measured on two orthogonal dimensions: valence (i.e., critical or confirmatory) and informational value (i.e., informative and uninformative). Findings shown in Table 3 indicate that the more the students chose critical feedback, the more they remembered both types of critical feedback (informative and uninformative) and the less they remembered both types of confirmatory feedback (informative and uninformative). Results for Revision are similar but weaker, with only the correlation with confirmatory informative feedback reaching statistical significance. Finally, the better the students performed, the more they remembered the critical uninformative feedback and the less they remembered the confirmatory uninformative feedback encountered in the game. Thus, critical informative feedback remembered correlated significantly with the choice to seek critical feedback, non-significantly with the choice to revise, and inversely and non-significantly with performance.

Table 3. Correlations between game measures and feedback memory measures by feedback type ($^{**}p < .01$, $^{*}p < .05$)

Measures (n = 73)	Critical Inf. Remembered	Critical Uninf. Remembered	Confirmatory Inf. Remembered	Confirmatory Uninf. Remembered
Critical Feedback	**.46****	**.31****	**-.36****	**-.52****
Revision	.17	.19	**-.28***	-.15
Poster Quality	-.01	**.25***	-.12	**-.37****

5.3 Does In-School Performance Correlate with Students' Memory for Critical Informative Feedback?

These analyses tested the hypothesis that students' in-school performance correlated with students' memory for critical informative feedback. Results of the Spearman correlations between students' in-school performance measures and their memory for feedback are shown in Table 4. Findings revealed that ELA-CST correlated with the critical informative feedback remembered and with the overall critical feedback remembered (*rho* = .28, $p < .05$). Also, Math-CST inversely correlated with the confirmatory informative feedback remembered and with the overall confirmatory feedback remembered (*rho* = -.33, $p < .01$). Thus, both school performance measures seem to be important for students' memory for informative feedback.

Table 4. Correlations between school performance and feedback memory by feedback type ($^{**}p < .01$, $^{*}p < .05$)

Measures (n = 65)	Critical Inf. Remembered	Critical Uninf. Remembered	Confirmatory Inf. Remembered	Confirmatory Uninf. Remembered
ELA-CST	**.25***	.13	-.15	.01
Math-CST	.05	-.01	**-.29***	-.11

6. DISCUSSION, LIMITATIONS, AND FUTURE WORK

In-game measures and feedback memory. Results showed that the critical feedback remembered correlated significantly with both in-game choices to seek critical feedback and to revise, and non-significantly with in-game performance. First, the more the students choose to seek critical feedback, the more critical, and the less confirmatory, feedback they remember. This seems to support the hypothesis that choosing critical feedback has a lasting impact on students' memory for critical feedback. Although not statistically significantly, the more the students choose critical feedback, the more feedback they remember in general. One limitation of the study is a lack of a tutorial round. Instead, students used the first round of the game to explore and understand the game mechanics. Thus, the measures on the first game round were not as consistent as the measures on subsequent levels. In future analyses, only the last two rounds of the game will be considered and the correlation between choosing critical feedback and the overall feedback remembered will be reexamined. Second, a similar pattern of results emerged for the choice to revise, supporting the hypothesis that the more the students chose to revise, the more they remembered their critical feedback. One possible explanation is that students mainly choose to revise when they engage with critical feedback, a result consistent with all Posterlet studies. Consequently, during the revision process, students may fill their knowledge gaps by translating the critical feedback they had chosen into action and, thus, remembering this

feedback better as a result. The next research question will test whether this result is due to the informative or uninformative value of critical feedback. However, between the two choices, results showed that seeking critical feedback is more important than revising for feedback memory, because only the choice to seek critical feedback significantly predicted the amount of critical and confirmatory feedback remembered. Third, performance showed a similar pattern of results as both choices, with the exception that the correlation between performance and memory for critical feedback did not reach statistical significance. This result contradicts the hypothesis that performance is positively associated with the critical feedback remembered. A future study will reexamine this correlation when only the last two rounds of the game are considered.

In-game measures and the informational value of feedback. Results showed that students' memory for critical informative feedback correlated significantly with their choice to seek critical feedback, non-significantly with their choice to revise, and inversely, non-significantly with their poster performance. First, the more the students choose critical feedback, the more critical (informative and uninformative) feedback and the less confirmatory (informative and uninformative) feedback they remember. This result supports the hypothesis that choosing critical feedback correlates with students' memory for critical informative feedback. Second, a similar pattern of results emerged for the choice to revise, but only the inverse correlation with the confirmatory informative feedback reached statistical significance. A possible explanation for this result is that students already know the information presented in the confirmatory informative feedback, so they do not need to attend to it nor to revise the graphic design principles included in the feedback, hence, they may not remember it as well. Third, results showed that the better the students performed on the poster design task, the better they remembered the critical uninformative feedback and the worse they remembered the confirmatory uninformative feedback. This counterintuitive result contradicts the initial hypothesis that performance is positively associated with students' memory for critical informative feedback and it points to a motivational aspect of feedback that requires further exploration. Follow-up analyses that consider only the last two rounds of the game will be conducted. A limitation of this study is that students could potentially receive more uninformative than informative feedback, because the feedback system alternates between informative and uninformative feedback of the same valence. Moreover, if no informative feedback can be generated (e.g., critical feedback is sought on a poster with no mistakes), then an uninformative feedback message of the same valence is generated. A future study will be designed to explore this aspect. Finally, an alternative explanation for these results is that individual differences might impact students' engagement with feedback more than the actual content of the feedback (Orsmond and Merry, 2013).

In-school performance measures and feedback memory. Results showed that both school performance measures seemed to be important for students' memory for informative feedback. First, students' standardized English Language Arts scores correlated with both the critical and the critical informative feedback remembered, supporting this study's hypothesis. Second, students' Mathematics scores inversely correlated with both the confirmatory and the confirmatory informative feedback remembered. One explanation for these results could be that students who perform well in arts are more open and accustomed to interacting with critical feedback and, hence, they remember it better, while students who perform well in mathematics are more inclined to filter out the information they already know.

Taken together, these results indicate that the learning environment is important for performance and feedback retention. Thus, when students have a choice regarding the valence of their feedback, the more they choose critical feedback, the more they remember critical (informative and uninformative) feedback and the less they remember confirmatory (informative and uninformative) feedback. In subsequent studies, the timing of the memory survey administration will be varied to gain an insight into how it affects students' memory for different types of feedback. Future research will also explore whether students remember critical and confirmatory feedback differentially when they are assigned feedback rather than in the current situation when they choose their feedback. Finally, future studies will examine the impact of other variables (e.g., mindset) on the valence and on the informational value of the feedback that students remember.

7. CONCLUSION

This research examined the impact of students' feedback choices and learning performance on their feedback memory. An empirical study was designed to collect students' learning choices via an assessment game, Posterlet, and their memory for feedback via a follow-up survey. Results provide evidence that choosing critical feedback is associated with better memory for critical feedback and worse memory for confirmatory

feedback. Also, the better the students perform in Posterlet and on Mathematics standardized tests, the less confirmatory feedback they remember. Finally, the better the students perform on English Language Arts standardized tests, the more they remember critical informative feedback. This research has implications for the design of assessments and instructional materials. Students may benefit from learning environments where they can engage proactively with feedback to improve their performance and their memory for the feedback content. Instructors may benefit from assessment environments that integrate the measurement of students' learning choices (e.g., willingness to seek critical feedback and to revise) and learning outcomes, so that they can evaluate programs of instruction. These findings could help explain why some forms of feedback are more effective than others and, thus, they may also aid researchers in gaining insights into the mechanisms of feedback processing and recall, and in comparing different feedback interventions.

ACKNOWLEDGEMENT

We are grateful to the participants, the Gordon and Betty Moore Foundation, and the NSF (Grant # 1228831) for their generous support.

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