

Feedback of Interface Agents on Student Perception: Level, Dialogue, and Emotion

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ABSTRACT

Although feedback from interface agents has recently attracted increasing research attention, most studies emphasize the cognitive influences. Thus, the effect of each feedback type on student perception remains unclear. This study focuses on three types of feedback from interface agents to clarify student perception of single feedback and combinations of feedback types. An empirical study of 45 junior college students was conducted. Results showed that students preferred the emotion feedback and disliked the level feedback when they were asked to choose one feedback type. For combinations, the combined feedback of dialogue and emotion was the most preferred among all combinations. Based on these findings, several implications for the further development of interface agents are discussed.

Keywords

Feedback, Interface agent, Student perception, Animal companion

Introduction

Interface design is regarded as having a crucial influence on the quality of the human-computer interaction (Preece, Rogers, & Sharp, 2002). For learning systems, interface design affects both student participation and the quality of the process, which further influences student learning achievement. Thus, enhancing the interface design of learning systems has become a significant issue. Furthermore, interface design has undergone many changes. First, the human-computer interface has developed from textural to graphical, multimedia, tangible, and gestured forms, where advanced technology has a great impact on the interface design. Second, because people tend to treat computers as social actors (Reeves & Nass, 1996), interface agents have been incorporated into the human-computer interaction (Preece, Rogers, & Sharp, 2002). Interface agents are embodied as virtual characters to play specific educational roles (e.g., tutor, tutee, and learning companions), attracting students' attention and fostering their participation and communication (Woolf, 2009).

To maximize the impacts of interface agents, these agents are equipped with different appearance, persona, and feedback. First, appearance has been shown to affect students' perception and participatory willingness when interacting with different visual forms (e.g., realistic or iconic) and visual styles (e.g., ethnicity and gender) of interface agents (Baylor & Kim, 2003; Baylor & Kim, 2005; Gulz & Haake, 2005). Second, the individual persona of interface agents is a key factor in student interaction because the individual personas of interface agents have their own "voice" in the interaction (Hietala & Niemirepo, 1998). For instance, the impact of the personas of "empathy" and "politeness" on student learning has been explored (McQuiggan & Lester, 2007; Wang, Johnson, Mayer, Rizzo, Shaw, & Collins, 2008). Third, the different types of feedback of interface agents have also been investigated. For instance, the feedback of body language (e.g., nodding, gestures, and eye contact) is used to enhance students' motivation and further facilitate their communication (Johnson, LaBore, & Chiu, 2004; Johnson, Rickel, & Lester, 2000). In addition, different feedback levels of behavioral realism (e.g., high/low realism, and mixed realism) are also investigated. Results show that believable feedback of behavior is a key factor in student perception and participation (Groom, Nass, Chen, Nielsen, & Scarborough, 2009).

Recently, an interface agent named animal companion (Chen, 2012; Chen et al., 2007) has attracted increasing research attention, because its feedback is based on emotional attachment to pets (Beck & Katcher, 1996; Melson, 2001), which further enhances students' participatory motivation (Chen et al., 2011). Moreover, visual appearance of educational agents could have a major impact on student motivation and affection (Baylor, 2009). Since animal companions own the visual features of simple and cute, they have also attracted college students, especially females (Chen, 2014). In addition, a set of animal companion systems with different types of feedback are explored: level, emotion, and dialogue feedback. For level feedback, animal companions use visual symbols, such as decoration (Liao et al., 2011), and badges (Chen et al., 2013) to represent student learning participation.

Such design is underpinned by the studies in which visual styles (e.g., reality, ethnicity, and gender) have been shown to influence student impressions (Baylor & Kim, 2003; Baylor & Kim, 2005; Gulz & Haake, 2005). For emotion feedback, it has been indicated that emotions will influence learning, and emotional feedback is a powerful educational tool that could enhance student learning (Economides, 2006). Animal companions use various facial emotions to represent student learning status, such as excited, happy, sad, and upset (Chen et al., 2007). This is because facial expressions use deeper emotions to engage students in effective communication (McQuiggan & Lester, 2007; Wang et al., 2008). For dialogue feedback, animal companions use conversations to convey students' learning status (Chen & Chen, 2013; Chen et al., 2007). Such design is supported by research showing that written or spoken conversation is a significant element of storytelling, a powerful communication or persuading narrative (Alexander, 2011), enabling animal companions to play various social roles (e.g., motivator, sustainer, goal-setter, reflector, and task facilitator) to interact with students (Chen et al., 2007).

However, although the aforementioned studies contribute to our understanding of feedback of interface agents on student learning, current studies lack a systematic evaluation of the feedback. Thus, the impact of each type of feedback remains unclear, although the combination of emotion and dialogue feedback (Chen, 2012; Chen et al., 2011) as well as the combination of level and emotion feedback (Liao et al., 2011) has been revealed to increase student motivation and learning performance. Because of individual differences, not all students have the same preferences for the use of learning systems (Chen, 2014; Yu et al., 2008; 2002). Thus, the design of learning systems should take adaptive feedback into account. However, before providing students with adaptive feedback, the effects of different feedback should be clarified. Hence, it is critical to investigate the influences of the feedback of interface agents on student learning.

In short, three significant feedback of animal companion systems (i.e., level, emotion, and dialogue feedback) are investigated in previous studies (Chen & Chen, 2013; Chen et al., 2013; Chen et al., 2007). Although the impacts of some combinations of the three feedback have been investigated, their influences of each single feedback are not systematically clarified. Thus, this system develops an animal companion as an example of interface agent to systematically examine student preferences across the three types of feedback. More specifically, this study attempts to answer the following two research questions: (1) *What are student preferences for interface agent feedback among level, emotion, and dialogue feedback?* (2) *What are student preferences for combinations of level, emotion, and dialogue feedback?*

Method

Settings

To answer the research questions, this study conducted an evaluation, in which all of participants experienced and assessed feedback of animal companion systems. To this end, two animal companion systems were developed: a single feedback (SF) system, and a combined feedback (CF) system. Both of them had the same subject domains: multimedia programming. During the process, the systems proposed a set of multiple-choice questions to assess students' concept understanding. Once the students chose one of the items, they would receive the feedback from animal companion systems. In the beginning, the students received one type of feedback each time to experience all types of feedback. Then, they could freely choose the feedback they preferred. In the single feedback (SF) system, the students were offered one of the three types of feedback (i.e., level, emotion, and dialogue). In the combined feedback (CF) system, students were offered a combination of the three feedback types, including level, emotion, dialogue, level & emotion, level & dialogue, emotion & dialogue, and level & emotion & dialogue. After students experienced the systems, they were asked to fill out questionnaires to report their perceptions.

Participants

Participants were 45 junior college students (aged an average of 20 years) from the department of information communication in a Taiwanese university. Since they all had similar backgrounds of computer and information skills, bias from different backgrounds of information technology literacy was reduced. In addition, the participations consisted of 25 males and 20 females to reduce gender bias.

Instruments

To clarify students' perceptions on single and combined feedback, for each system the students were asked to answer a number of multiple-choice questions, where they could freely choose feedback types. In other words, the students could choose one of the three feedback types in the SF system during the process, whereas they could choose among the combinations of the three feedback types in the CF system. Thus, the major difference between the two systems lied in the number of feedback types that students could choose during the learning process. As illustrated in Figure 1, each system consists of three different feedback types (level, dialogue, and emotion), which are described below:



Figure 1. Animal companion system with three types of feedback

- **Level feedback:** The design of level feedback is based on the concept of mastery learning, in which materials to be learned are divided into short units, and students are evaluated on their progress for each unit of materials (Bloom, 1968; Kulik et al., 1990). In this study, the level feedback of animal companions is divided into nine levels to show students' mastery levels. Nine different degrees of level feedback are used to illustrate students' overall learning status according to their accuracy rate. In addition, to enhance students' confidence in mastery and progressing, the intervals of the first five levels (Level 1~5) are defined as 10%, whereas the last four levels (Level 6~9) are defined as 15%. Through the level feedback, students' overall learning status can be illustrated directly and clearly.
- **Emotion feedback:** The design of emotion feedback is referred to a previous study of animal companions (Chen et al., 2007), where the emotions of animal companions are classified as a linear model with two dimensions: positive and negative dimensions. More specifically, the positive dimension contains three emotions (i.e., excited, happy, and smile), whereas the negative dimension also contains three emotions (i.e., confused, sad, and crying). The use of this linear model is to highlight students' current level of performance and the direction for further improvement. In addition, these six emotions are classified as two categories: instant feedback and overall status. The former will present "happy" or "sad" to students when they get a correct/wrong answer. The latter shows the students' accuracy rate—using six different emotions, including excited (85%~100%), happy (70~84%), smile (60%~69%), confused (40%~50%), sad (20%~39%), and crying (1%~20%). These facial emotions are illustrated in Figure 2.

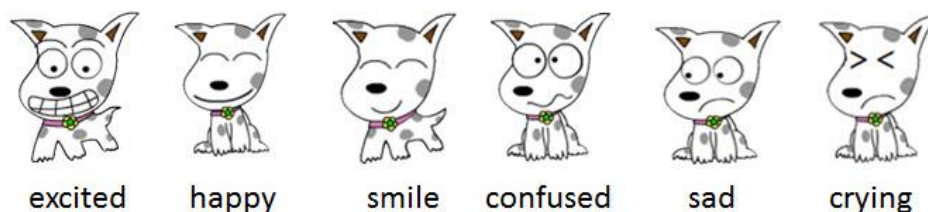


Figure 2. Emotional feedback of animal companions

- **Dialogue feedback:** Two categories of facial emotions are used for dialogue feedback. Instant feedback such as "Congratulations! You are right!" or "That's OK, never give up!" would show whether a student's

answer is correct. In addition, as with level feedback, overall learning status based on their correct answer percentage is used. For instance, while students' correct ratio increase to 85%~99%, the agent will say "Excellent! You did that very well." But if the correct ratio is around 40~59%, it would say "Kept on trying! I know you can do it." The dialogue feedback can show students' learning status in the way of conversation.

Data collection

To understand student perceptions of the learning system with different feedback types, two perception questionnaires were developed by the authors of this paper: single-feedback questionnaire and combined-feedback questionnaire. The single-feedback questionnaire contained 15 items evaluating the effect of the three feedback types on student perception. These items are categorized as five aspects according to the educational roles that animal companions might play, such as facilitator, motivator, and reflector (Chen et al., 2007). More specifically, five aspects of learning perception were emphasized, including preferences, performance, motivation, reflection, and pressure. Each item was scored on a 5-point scale ranging from "Strongly Disagreed (S.D., point = 1)", "Disagreed (D., point = 2)", "Neutral (N., point = 3)", "Agreed" (A., point = 4) to "Strongly Agreed" (S.A., point = 5). The combined-feedback questionnaire contained 5 items on student perceptions of the effect of the combined feedback types on preferences, performance, motivation, reflection, and pressure. The collected data was analyzed via one-sample t-test to examine whether students' choices were significantly different. These analyses were conducted using Statistical Package for the Social Science (SPSS v17).

Procedure

The following procedures were employed in this study: (1) SF system usage: before using the learning systems, the students were given a brief instruction for ten minutes. They then used the SF system for twenty minutes. To help students emphasize the observation of different feedback provided by the system, they were asked to do the practical tasks, in which they need to answer a number of multiple-choice questions about the basic concepts of multimedia programming language. (2) Single-feedback questionnaire: The students were asked to fill out the single-feedback questionnaire for ten minutes. (3) CF system usage: as with the SF system usage, the students were asked to use the CF system for twenty minutes to complete the practical tasks. (4) Combined feedback questionnaire: the students were asked to do the multiple-feedback questionnaire for five minutes. These procedures are illustrated in Figure 3.



Figure 3. Study procedure

Results

Students' perception of single feedback

Table 1 presents the means of student preferences on single feedback. The results of the one-sample t-tests revealed that the scores for emotion feedback were significantly higher than the normal distribution ($t = 2.982$, $p < .01$), which implied that students had significant preference for emotional feedback, but did not have obvious preferences for the other two types of feedback.

Table 1. Preference scores for the three feedback types

	# of S.D.	# of D.	# of N.	# of A.	# of S.A.	Mean	<i>t</i>
Level	2	8	28	7	0	2.88	-1.044
Emotion	1	2	24	16	1	3.32	2.982**
Dialogue	1	4	28	12	0	3.13	1.354

Note. ** $p < .01$.

Table 2 illustrates the means of student helpfulness scores for single feedback. The results of the one-sample *t*-tests showed that the score for dialogue feedback was higher than the normal distribution ($t = 2.052$, $p < .05$), whereas the scores of the other feedback types were not. These results implied that dialogue feedback enhanced helpfulness for students.

Table 2. Helpfulness scores for the three feedback types

	# of S.D.	# of D.	# of N.	# of A.	# of S.A.	Mean	<i>t</i>
Level	3	2	24	16	0	3.18	1.48
Emotion	3	1	24	16	1	3.24	1.976
Dialogue	4	2	17	21	1	3.29	2.052*

Note. * $p < .05$.

For motivation, the results and one-sample *t*-tests did not demonstrate significant differences for each type of feedback (Table 3). This implies that students did not experience enhanced motivation in using the three types of feedback. Table 4 illustrates the means of reflection for single feedback. The one-sample *t*-tests demonstrated that level and dialogue feedback had statistically significant differences. These results imply that the two feedback types fostered student reflection.

Table 3. Motivation scores for the three feedback types

	# of S.D.	# of D.	# of N.	# of A.	# of S.A.	Mean	<i>t</i>
Level	3	3	23	15	1	3.18	1.386
Emotion	4	1	24	14	2	3.20	1.459
Dialogue	3	4	22	14	2	3.18	1.308

Table 4. Reflection scores for the three feedback types

	# of S.D.	# of D.	# of N.	# of A.	# of S.A.	Mean	<i>t</i>
Level	2	1	15	19	2	3.46	3.376**
Emotion	3	2	20	14	0	3.15	1.138
Dialogue	2	0	19	17	1	3.38	3.072**

Note. ** $p < .01$.

In addition, Table 5 shows the means of student pressure for single feedback. The one-sample *t*-tests showed that the score of level feedback was higher than the normal distribution ($t = 2.052$, $p < .05$), whereas the scores of others were not. This result implies that level feedback made the students feel pressure.

Table 5. Pressure scores for the three feedback types

	# of S.D.	# of D.	# of N.	# of A.	# of S.A.	Mean	<i>t</i>
Level	2	3	17	16	1	3.28	2.056*
Emotion	2	11	18	7	1	2.85	-1.098
Dialogue	2	6	18	11	2	3.13	0.8676

Note. * $p < .05$.

Students' perception of combined feedback

Table 6 illustrates the students' choices for combined feedback. For helpfulness, motivation, and awareness, the combined feedback of "emotion and dialogue" was the one chosen most by students (34%, 32%, 28%, and 23%, respectively). For pressure, the results show that level (13, 30%) and dialogue (10, 23%) were the models chosen by most students. This suggests that the level and dialogue feedback made students feel more pressure.

Table 6. Student perception of feedback combinations

	Preference	Helpfulness	Motivation	Awareness	Pressure
Level	4 (9%)	7 (16%)	6 (14%)	7 (16%)	13 (30%)
Emotion	6 (14%)	2 (5%)	4 (9%)	2 (5%)	0 (0%)
Dialogue	5 (11%)	5 (11%)	5 (12%)	5 (12%)	10 (23%)
Level and Emotion	6 (14%)	6 (14%)	5 (12%)	6 (14%)	3 (7%)
Level and Dialogue	4 (9%)	6 (14%)	6 (14%)	8 (19%)	8 (18%)
Emotion and Dialogue	15 (34%)	14 (32%)	12 (28%)	10 (23%)	9 (20%)
Level, Emotion and Dialogue	4 (9%)	4 (9%)	5 (12%)	5 (12%)	1 (2%)
Total	44 (100%)	44 (100%)	43 (100%)	43 (100%)	44 (100%)

In sum, comparing the findings of single feedback with combined feedback shows that: (1) Although level feedback could directly and clearly reveal student status, most students felt this feedback also resulted in more pressure. (2) Because dialogue feedback could describe students' status in detail, it was regarded as the mode that enhanced helpfulness and reflection. However, dialogue feedback also made students feel more pressure. (3)

Since emotion feedback can show student status in a kindly manner, most students preferred this feedback. In addition, emotion feedback eased the pressure while students learned. (4) Among the combination of multiple feedbacks, the combined feedback of “emotion and dialogue” was the most popular among all of combinations, which implies that “the more, the better” is not always true in the design of interface agent feedback systems.

Discussion

Cognitive and affective impacts

Interface agents are computer-simulated figures that interact with students to enrich their individual learning by acting as social participants (Chou, Chan, & Lin, 2003). From this definition, interface agents are devoted to playing various social roles (e.g., tutor, tutee, companion, motivator, sustainer, goal-setter, reflector, and task facilitator) to interact with students (Chen et al., 2007). Nevertheless, a core part of these social interactions is to communicate and persuade students, which requires student acceptance of agents’ feedback. Such communication is often supported by multimedia technology. For instance, multimedia learning (Mayer, 2009) asserts that optimal learning occurs when visual and verbal information is presented together simultaneously, because students have separate channels to process visual and verbal information. In other words, when visual and verbal forms are linked together, students’ comprehension (Rusanganwa, 2013) can be enhanced, and information can be stored in long-term memory (Kulhavy, Stock, & Kealy, 1993). In addition to the aforementioned cognitive impacts, the development of interface agents should also consider students’ perception from the affective perspective because improving students’ learning performance is insufficient to attract them to use learning systems (Bull & Kay, 2007; Bull & McKay, 2004). Thus, there is a need to provide students with engaging and acceptable learning experiences in interacting with interface agents.

In this study, emotion feedback was the favourite feedback. Students also preferred the combined feedback of emotion and dialogue, rather than the view from the cognitive impacts: “the more, the better.” A possible explanation was that obvious and direct feedback resulted in learning pressure, which affected student preferences. Several previous studies have demonstrated the cognitive impacts of interface agents on student learning (Graesser et al., 2008; Woolf, 2009). This study further clarifies findings from the affective perspective: (1) Although the combination of feedback types has been shown to affect student motivation and performance (Chen, 2012; Chen et al., 2011; Liao et al., 2011), this study examined students’ perceptions for each feedback. The results showed that the emotion feedback was more popular than dialogue and level feedback. (2) Level feedback generated greater learning pressure than the other two feedback types. These findings might be helpful to the further development of interface agents, especially from the affective perspective.

Technological and pedagogical issues

In addition to the development issue of interface agents, it is also important to further interpret the implications of the application of interface agents, especially from the perspectives of advanced technologies and pedagogical strategies. With advanced technologies, the technologies used in constructing interface agents can be quite different. Nevertheless, reviewing the phenomenon of Tamagotchi (Webster, 1998; Pesce, 2000) shows that using which technologies is less important. Instead, whether students can build close relationships with these interface agents is more critical. This is because such close relationships can contribute to human-computer interaction, including enhanced interactivity (Trappl, Petta, & Payr, 2001), social participation (Gulz, 2005), adaption to students’ feelings (Bichmore, 2003; Bichmore & Picard, 2004), and friendship with computers (Stern, 2002). Previous studies have suggested that a set of relations (e.g., tutor-to-tutee, peer-to-peer, mother-to-child, master-to-pet, and gardener-to-plant) can be used to underpin the design of interface agents (Chen & Chen, 2013).

For pedagogical strategies, the results of this study indicated that students preferred emotion feedback, rather than level and dialogue feedback. This conclusion correlates quite well with the central ideas and experience of the System of Emotional-Imaginative Teaching (the EIT-system), which was developed in the 1990s in Russia by Fomichova and Fomichov (Fomichov & Fomichova, 1995; 1997; Fomichova & Fomichov, 1996; 2000) and has been successfully used in practice for at least 25 years (Fomichov & Fomichova, 2012; 2014; Fomichov, 2015). In particular, the practice of using the EIT-system shows that establishing the links between the rules of English grammar and social conventions (such as dress code, etiquette, table manners, behavioral peculiarities) as a part of the world’s conceptual picture of the students makes the process of learning much more personal and, as a result, greatly influences student’s learning achievement and is highly appreciated by the students.

Our study shows that direct and obvious (e.g., level and dialogue) feedback is not welcome, whereas moderate and kind (e.g., emotion) feedback is preferred. Hence, when incorporating pedagogical strategies into interface agents, educational goals should be considered to make good use of different feedback types. The findings of this study further suggest: (1) Although students did not prefer the dialogue feedback, the dialogue feedback can convey information in detail. Thus, the dialogue feedback may be used with emotion feedback to convey information to students. (2) Interface agents can be developed based on the aforementioned relationships, with feedback taking into account the chosen relationships. For instance, animal companions used in this study were developed based on the relationship of master-to-pet. Unlike a strict tutor, animal companions play the role of “companion” in student learning. Thus, the feedback of animal companions should be consistent with the settings of animal companions: moderate in tone, to remind students of their learning status. Other relationships and feedback types should be explored in the future.

Conclusion

This paper answers two research questions. For the first research question (i.e., *what are student preferences for interface agent feedback among level, emotion, and dialogue feedback?*), the results demonstrated that the emotion feedback was the favourite among the three feedback types, while level feedback resulted in the most pressure among the three feedback types. For the second research question (i.e., *what are student preferences for combinations of level, emotion, and dialogue feedback?*), the results revealed that the combined feedback of “emotion and dialogue” was the most popular among all combinations of feedback.

The limitations of study suggest areas for further investigation in the future. First, this study is a short-term study on student perceptions of interface agents. The long-term effects remain unclear. Thus, more research is required to examine their consistency. Second, since this study has a small sample size, further investigation with a large sample size is required. Third, this study uses animal companions as an example of interface agents, which cannot reflect the characteristics of other interface agents, although it offers a starting point to investigate their impacts. Thus, a number of different types of interface agents should be examined in future studies. Finally, since students’ preferences will influence their perceived feedback, which could further effect how they acquire knowledge and lead different learning outcomes. Therefore, in the future, students’ learning outcomes should be investigated while they obtain different feedback.

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