The Influence of Augmented Feedback on Skill Learning Depends on Characteristics of the Skill and the Learner

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Augmented feedback is a common component of the communication between instructor and student in skill learning. In this article, the argument is made that the effective use of augmented feedback depends on understanding the various effects of augmented feedback on skill learning and the conditions characterizing the occurrence of each effect. Four distinct relationships between augmented feedback and skill learning are presented: Augmented feedback is necessary for learning some skills; it is not needed to learn some skills; for some skills it enables the learner to acquire the skill faster or achieve a higher level of performance than would be possible without it; and it can be provided in such a way that it hinders skill learning. These four relationships are also discussed in terms of their implications for skill instruction.

It is common to provide people learning skills with some type of feedback about their skill performances. When used in this way, feedback can be referred to as augmented feedback, although a variety of other terms have been used to refer to the same type of externally presented feedback (see Magill, 1993). Augmented feedback is commonly used in "real-world" skill-learning situations as a communication method and has both anecdotal and empirical support (e.g., Fishman & Tobey, 1978; Lee, Chin, & Magill, 1993). However, it appears that researchers and practitioners do not fully understand that augmented feedback can have a variety of influences on skill learning, positive or negative. In fact, augmented feedback has traditionally been given a two-part role in skill learning. One part is that augmented feedback is necessary for effective skill learning to occur. The second is that augmented feedback is beneficial for skill learning.

These two traditional characteristics of augmented feedback can be seen in statements made in influential theories of motor skill learning, as well as in

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influential teaching methods textbooks in physical education. For example, two
theories of motor skill learning that continue to influence a large number of
researchers and practitioners are those by Adams (1971) and Schmidt (1975).
Adams proposed that for skill learning to occur, knowledge of results (KR) is a
necessary type of information that must be provided to the learner. For my
purposes, the terms **augmented feedback** and **KR**, can be interchanged, as the
KR was the type of augmented feedback used in the experiments on which
Adams based his theory. Schmidt (1975) reinforced this viewpoint in his schema
theory by similarly supporting the necessity of KR for skill learning. Later,
Schmidt (1989) stated that another type of augmented feedback, knowledge of
performance (KP), could also be expected to have a relationship with skill learning
similar to KR. These propositions are in step with earlier views of augmented
feedback, which can be represented by a statement made by Ina Bilodeau (1969),
a highly regarded researcher in motor skill learning circles. She concluded from
a review of the research literature that augmented feedback is “the strongest,
most important variable controlling performance and learning” (p. 282).

The impact of the view projected from motor skill learning theories and
research that augmented feedback is necessary and beneficial for skill learning
can be seen in the pedagogical literature. For example, in a highly regarded
teaching methods textbook for physical education teachers, Siedentop, Herkowitz,
and Rink (1984), stated that “it has been known for some time that feedback is
necessary for learning. . . . Physical educators must learn to be expert deliverers
of feedback” (pp. 11-12). In another well-respected textbook, Rink (1985) told
prospective physical education teachers that “feedback is an absolutely essential
ingredient for learning” (p. 241).

The point to be made in this article is that the statements made by Adams
(1971) and by Schmidt (1975, 1989) are incorrect and that the statements made
by the textbook authors cited are at worst incorrect and at best incomplete. To
make this point, research literature will be reviewed to describe the specific
effects of augmented feedback on skill learning. What will be seen is that aug-
mented feedback is not always necessary and beneficial for skill learning. In
fact, four different relationships between augmented feedback and skill learning
exist. Fortunately, these different relationships can be related to specific character-
istics of the skills being learned and, in some cases, to the characteristics of the
learners to whom the feedback is directed. From a motor skill learning perspective,
this categorization of relationships provides a more appropriate base on which to
develop theory and research. From a pedagogical perspective, viewing augmented
feedback in this way provides direction for determining the appropriate use of
augmented feedback to help establish optimal learning conditions.

**Questioning the Traditional Role Given Augmented Feedback**

Before looking at the specific relationships between augmented feedback and
skill learning, it will be instructive to consider some bases for questioning the
traditional role given augmented feedback. While the discussion about the different
types of influences of augmented feedback on skill learning will reveal empirical
evidence arguing against the traditional role, there are additional reasons for ex-
pecting that augmented feedback may not always be necessary and beneficial for
skill learning. These reasons are revealed in both motor learning and physical education pedagogy literature.

The first reason comes from an influential review of the KR literature by Salmoni, Schmidt, and Walter (1984). This review sets the stage for the present discussion because it established that the commonly referred to principles of KR "are at best in need of some conceptual rearrangement and at worst largely incorrect" (Salmoni et al., p. 365). They demonstrated that different conclusions about these KR principles could be derived when the research literature was examined in terms of whether the KR effects were on performance during practice or on performance during retention or transfer tests. While this important review did not suggest altering the view that augmented feedback is necessary and beneficial for skill learning, it did open the door for concern about all traditionally held views related to the influence of augmented feedback on skill learning.

A second cause for questioning came from a theoretical perspective of skill learning and control that is an alternative to the theories of Adams and Schmidt. Known as action theory or dynamic systems theory (e.g., Meijer & Roth, 1988), this view of skill control argues that the theories of Adams and Schmidt have ignored both the wealth of environmental information available to people who are performing skills and how that information influences skill learning and control. As a result, this view downplays the role of augmented feedback in skill learning and emphasizes the positive role played by environmental information in the interaction between the sensory-perceptual system and the motor-control system. Because individuals use this environmental information to guide their actions, the need for augmented information takes a secondary role in skill learning. Hence, the traditional role given augmented feedback is dismissed and a lesser role is proposed.

Finally, the belief that augmented feedback is necessary and beneficial for skill learning can be questioned by considering what occurs within a physical education class environment. According to teacher behavior research in physical education, a teacher gives only about one or two feedback statements per minute in a class, and these statements are not equally distributed among all students in the class (e.g., Fishman & Tobey, 1978; Lee et al., 1993; Silverman, 1994). Some students receive no feedback from the teacher while others may get many feedback statements during a class period. Yet, when improvement in performance or achievement are correlated with the amount of feedback received, the result is that there is no strong relationship between these variables (Lee et al., 1993). This means that in physical education teaching situations, there is no conclusive evidence indicating that the degree of skill learning by students depends on the amount of or type of teacher feedback the students received.

Taken together, these three different but related pieces of evidence call into question the view that augmented feedback is necessary and beneficial for skill learning. If this view inappropriately describes the role of augmented feedback in skill learning, then the question becomes, What is the appropriate view of that role? The following sections will address this question by showing that rather having one role, augmented feedback can actually play four different roles in skill learning. The role it plays depends largely on certain characteristics of the skill being learned and of the person learning the skill.
Four Relationships of Augmented Feedback to Skill Learning

Despite the proposal that the view of augmented feedback as necessary and beneficial for skill learning is not appropriate, there are certain skills for which augmented feedback is essential for learning. For these skills, no learning occurs without augmented feedback. This influence of augmented feedback is illustrated by the following two examples of experimental evidence. These examples also demonstrate the types of skill characteristics that indicate when learning a skill requires augmented feedback. Both examples involve laboratory tasks, and both follow a similar procedure to demonstrate the need for augmented feedback, which is KR in both cases. This procedure is to withdraw (i.e., not provide) KR after different amounts of practice. If KR is necessary for learning these skills, then withdrawing KR too early in the learning process should lead to not learning the skill.

In an experiment by Bilodeau, Bilodeau, and Schumsky (1959), subjects were required to learn to move a lever to a specific position while they were blindfolded, thereby establishing a laboratory version of a blind limb positioning task, which often characterizes real-world performance situations. After each attempt at positioning the lever at a location the subjects estimated to be the correct position, they were given KR in terms of how much too short or too far they went. One group of subjects received no KR, while two other groups had KR withdrawn after 2 and 6 trials, respectively. A fourth group received KR for all 20 practice trials. The results showed that performance deteriorated as a function of when the KR was withdrawn and that receiving no KR led to no improvement. Thus, without external information about the correctness of a practice attempt, learning this limb-positioning skill did not occur.

A similar procedure was followed by Newell (1974) for a different task. In this experiment, subjects were not blindfolded and were required to learn to move a lever a specified distance (24 cm) in a criterion amount of time (150 ms). KR was in terms of the amount of time too early or late of the criterion. There were six KR withdrawal conditions ranging from KR withdrawn after only 2 trials to KR not withdrawn at all for the entire 75 practice trials. KR was withdrawn for the other four conditions after 7, 17, 32, and 52 trials. The results were similar to those reported by Bilodeau et al. (1959). When KR was available for only 2 trials, there was no improvement in the skill. In fact, subjects in this condition got worse during practice. Also, the amount of improvement was a function of the amount of practice trials for which KR was provided. One interesting result was that there was no difference between the group receiving KR on all trials and the group having KR withdrawn after 52 trials. In keeping with predictions by Adams’s (1971) theory, KR was used as the basis for developing a memory representation of the correct limb movement speed, which could eventually be used to produce the movement in the absence of KR.

Together, these two experiments indicate that learning certain types of skills requires augmented feedback. Two features characterize the two skills used in these experiments. One feature is that the sensory information needed to determine the appropriateness of an action was not available while performing...
the skill. In the Bilodeau et al. (1959) experiment, subjects could not determine the criterion limb position without vision and were therefore dependent on external information that augmented the proprioceptive information from the moving limb. The other feature is that information critical to learning the skill could not adequately be used by the subjects. In the Newell (1974) experiment, the goal of the task was to move the lever in a specified number of milliseconds. It can safely be assumed that the subjects had little understanding of the relationship between milliseconds and arm movement speed. They had to learn this relationship as they practiced the skill. The KR provided a means for them to acquire this knowledge.

These two characteristics of the tasks used in the two experiments described above suggest when augmented feedback is necessary for skill learning. One situation occurs when the skill being learned must be performed under conditions in which essential sensory feedback is not available. For example, limb position is very important for a person learning to serve a tennis ball. But, because of the location of the limb during the stroke, visual feedback is not available, and the learner must determine limb position from proprioceptive feedback. For the beginner, proprioceptive information alone is not very useful. Thus, information about limb position during the serve stroke must come from an external source. Eventually, the person will learn to interpret and use the limb’s proprioceptive information and will not need augmented feedback about limb position. Similar blind limb position situations exist when learning to throw a ball, hit a golf ball, produce a swimming stroke, and so on.

The second situation involves an important characteristic of the person learning the skill. Augmented feedback becomes essential for learning when the learner lacks prior knowledge about the relationship between the goal of an action and the movements required. Examples of this situation include learning to throw a ball at a particular speed, or learning to run at a specific pace. In these types of situations, the critical learner characteristic is not whether the person is a beginner or is skilled, it is whether the person has the appropriate prior knowledge necessary to produce the action that will lead to the desired goal.

Not Necessary for Skill Learning

There are skills for which the environment or some non-feedback-related source provides sufficient information to learn the skill. Two examples of research investigations demonstrating these situations illustrate how it is possible to learn certain types of motor skills without augmented feedback. For these two investigations, one skill was a laboratory task, and the other was a real-world skill. The benefit of considering both types of skills is that generalizing experimental results to learning sport skills becomes a less venturesome leap and gains more ecological validity, especially given that some practitioners and pedagogy researchers have come to demand relationships between skills used in experiments and those learned in the “real-world” before having confidence in such generalizations.

The study involving a laboratory task is a series of four experiments reported by Magill, Chamberlin, and Hall (1991). In each experiment, subjects performed a coincident-anticipation task, which required them to strike with a hand-held bat a small wooden barrier on a tabletop at the same time a series of LEDs lighting in sequence along a wall-mounted trackway, arrived at a target light
directly in front of the subject. The sequence of lights moved at eye-level at a specified constant speed from the subject's left to the subject's right. The sequential lighting of the LEDs simulated a moving object, which is the phi phenomenon in psychophysics. KR was provided as the number of milliseconds the subject hit the barrier early or late of the target light illuminating. The experimental design was based on one by Newell (1974) in which KR either was available on all 75 practice trials or was withdrawn after specific amounts of practice.

Four experiments were based on the number of trackway speeds subjects experienced during practice and on whether the test after practice involved performing at the practiced trackway speed or speeds or at novel speeds, all without KR. Experiments 1 and 3 required subjects to learn to hit the barrier with only one trackway speed experienced for 75 trials, whereas Experiments 2 and 4 required subjects to learn to hit the barrier with three trackway speeds experienced randomly for the 75 trials. Experiments 1 and 3 also involved a retention test given 1 day later for the speed or speeds practiced, while Experiments 2 and 4 involved a novel transfer test 1 day later for one speed faster and one speed slower than those practiced. The results of all four experiments were consistent in showing that regardless of the number of trackway speeds practiced or the type of test experienced, KR was not essential for learning the skill. Regardless of when KR was withdrawn, there were no statistical differences between KR-withdrawal conditions for any of the retention or novel transfer tests.

In each experiment, subjects could assess critical information from the task itself (i.e., task-intrinsic feedback) about the relationship between the target light and the timing of their striking the barrier. This means that subjects did not need KR about this relationship to learn the task. Interestingly, according to interviews, subjects were not consciously aware of this relationship. This anecdotal evidence has been verified with some recent pilot experiments done in our lab showing a very poor relationship between subjects' estimates of their timing error and their actual error while performing this task.

Another experiment that demonstrates that learning a complex motor skill can occur without the aid of augmented feedback was reported by Magill and Schoenfelder-Zohdi (in press). University female subjects learned a basic rhythmic gymnastics rope skill that involved eight specific components. Two groups of subjects observed a videotaped expert model performing the skill, while two other groups received detailed verbal instructions describing the skill but did not observe the expert model. Subjects watched the videotaped model or heard instructions read to them before beginning to practice and then after each 6 trials of the 54 practice trials. One group of subjects who observed the model and one group who received verbal instructions received a prescriptive KP statement after each practice trial. This statement briefly described how to correct what the experimenter observed as the most critical error made on that trial, as determined from a prioritized list of errors for the skill. The remaining two groups, one that observed the model and one that received verbal instructions, did not receive any augmented feedback during practice.

Following a 1-day interval, subjects performed a retention test for 24 trials during which no group observed the model, received verbal instructions, or received KP. The results showed that the group who received verbal instructions but did not get KP demonstrated very little improvement and performed statistically worse than the other three groups during practice and on the retention test.
The other three groups all showed good improvement and did not differ from each other on the retention test. These results indicate that the rhythmic gymnastics rope skill could be learned in the absence of augmented feedback if the subjects observed a skilled model perform the skill. When the model could not be observed, augmented feedback was required to supplement the verbal instructions.

The two research investigations described here reflect two very different situations, although both demonstrate learning without the need for augmented feedback. In the experiments by Magill et al. (1991), the task itself provided the feedback needed to learn the skill, even though subjects picked up that information in a nonconscious (i.e., implicit) manner. In the experiment by Magill and Schoenfelder-Zohdi (in press), it was not task-intrinsic feedback that was critical but the type of instructions about how to perform the skill. When instructions were in the form of a skilled model performing the skill correctly, augmented feedback was not needed. In fact, there was no difference in learning between the groups who observed the model and received KP and those who observed the model but did not receive KP. What this means is that observing the skilled model provided subjects a means for establishing a memory-based reference against which they could compare their own performance.

The evidence from these two studies indicates that there are indeed situations in which people can learn skills without the aid of augmented feedback. One of these situations occurs when the skill itself provides sufficient task-intrinsic feedback to enable learning to occur. Another situation occurs when a demonstration is provided that shows the learner how the skill is performed correctly. It is very likely that augmented feedback will not be needed to learn skills in situations such as these. What is common to each situation is that some form of external referent is available that enables the performer to determine the correctness of an action. For the anticipation timing task, the task itself was the external referent. The performer was able to “see” which LED was illuminated when he or she struck the target. Although it may not have been conscious, a comparison between the time of striking the barrier and which LED was illuminated occurred, which was sufficient to enable performance improvement and learning. In the case of learning the rhythmic gymnastics rope skill, the external referent was not the task itself but a skilled model performing the skill. The modeled performance became the reference against which the learner could compare a practice attempt and then base corrections to be attempted on the next trial.

Enhancing Skill Learning

There are motor skills that, although they can be learned without augmented feedback, can be learned more quickly or to a higher level of performance if augmented feedback is provided. If the full range of sport skills were assessed, most would likely fall into this category. Some form of augmented feedback is beneficial for learning these skills. Two research examples, one involving a laboratory task and the other a sport skill, illustrate the types of skills that can be placed into this category. Each of these skills includes characteristics that make it possible to establish criteria that indicate when augmented feedback should be presented to improve learning.
The laboratory task used in an experiment by Stelmach (1970) required subjects to move one arm through a specified three-segment pattern along a tabletop as fast as possible. Subjects initiated their movement at a starting position, then moved forward 28 cm to hit a piece of rubber tubing, then back to a response button near the start position. One group received KR of the total movement time for making the three-segment movement. The other group did not receive any augmented feedback. The results showed that both groups improved during the practice trials. However, there were two distinct differences between the groups. First, the group that received KR improved at a faster rate than the group that did not receive KR. Second, the group that received KR achieved a faster movement time than the other group. Both groups began practice performing the task in just under .8 s. The no-KR group members improved their movement time to about .55 s. It took them about 25 trials to achieve this level of performance, which they maintained for the next 20 trials. The KR group, on the other hand, achieved a .55 movement time in about 10 trials and continued to improve to be able to complete the pattern in less than .48 s.

In an experiment by Wallace and Hagler (1979), subjects learned a basket-ball set shot with their nondominant hand while standing 3.03 m from the basket and 45° to the left side of the basket. Two groups of subjects received different forms of augmented feedback. One group received knowledge of performance (KP), which told subjects what was wrong about their stance and arm movement on each shot. The other group was given social reinforcement statements after each shot. These were verbal encouragement types of statements, such as “Good shot,” “You can do it,” “Try harder next time,” and so on. For the first 25 practice trials, both groups showed similar improvement. However, from that point on, the verbal encouragement group improved no further, while the KP group continued to improve, even on a retention test in which no KP was given.

For the two skills used in these two experiments, there was sufficient task-intrinsic feedback available to enable the subjects to discover how to improve their performance during practice. But the availability of augmented feedback, especially in a form that provided information that allowed specific skill improvement to occur, enabled subjects to perform beyond that level. And, in the case of the movement time task in the Stelmach (1970) experiment, subjects who received augmented feedback made this improvement at a faster rate.

There appear to be two messages here. First, there are skills that can be learned to a certain level without the aid of augmented feedback. These skills provide sufficient task-intrinsic feedback to enable learners to improve performance. But, there is an upper limit for this improvement. To achieve a higher level of performance, augmented feedback must be provided. Second, all types of augmented feedback will not have the same enhancing effect on skill learning. The information provided by the augmented feedback must give learners a basis on which to change some characteristic of their response so they can continue to improve performance.

**Hindering Skill Learning**

A frequently forgotten characteristic of augmented feedback is that it can hinder skill learning. In some cases, people would learn the skill better if they had not received the augmented feedback, and in other cases they would learn
the skill better if they had received a different type of or schedule of augmented feedback. Here again is an example in which the type of augmented feedback becomes a critical concern. Because there are several different types of situations in which augmented feedback can hinder learning, three examples of research evidence will be described here to illustrate this effect.

The first example shows how different types of augmented feedback can produce drastically different learning effects. In a series of experiments by Annett (1959), subjects learned to produce a criterion amount of force with their preferred hand either by depressing a movable plunger or pressing against a fixed metal bar. In one experiment, a group received augmented feedback on the amount of force produced while the movement was in progress. This concurrent form of augmented feedback was provided graphically on an oscilloscope during each practice attempt. Another group received verbal information about the amount of force produced at the completion of each practice attempt. At the end of the practice trials, both groups were performing with virtually no error. Both groups were then required to perform the skill without any augmented feedback. During these trials, performance deteriorated immediately for the group that had been given concurrent visual augmented feedback during practice. Their amount of error increased dramatically, but there was little change in performance for the other group. Thus, two different forms of augmented feedback led to very different effects on learning the force-production task. One group learned the skill quite well, while the other showed virtually no learning at all.

Another example of augmented feedback hindering learning was demonstrated by Buekers, Magill, and Hall (1992). Using the same coincident-anticipation timing task used by Magill et al. (1991) described earlier, Buekers et al. (1992) showed that when KR was erroneous performance information, it had a negative effect on learning. While this result may seem self-evident, what makes it notable is that the erroneous KR influenced learning even though KR was not needed to learn the skill. The erroneous KR involved telling subjects they struck the barrier 100 ms later than they actually did. One group of subjects received this erroneous information after each trial beginning on the first practice trial for 75 trials. The effect was that subjects developed a new performance criterion. In effect, subjects ignored their own visual feedback and based performance exclusively on the augmented feedback.

A very interesting group of subjects received correct KR for the first 50 trials (which led them to perform the task very accurately), but were then switched to receiving the erroneous KR. The subjects were not told about this switch. Here again, subjects chose to ignore their visual feedback. They also ignored what they had learned during the first 50 trials. As soon as the erroneous augmented feedback was given, subjects' performances quickly changed to follow the erroneous information. Remarkably, the effect of the erroneous feedback was long lasting. On a retention test given one week later, without KR, both of the groups that had received the erroneous KR during practice continued to perform the skill according to the erroneous KR criterion.

Finally, a third situation in which augmented feedback can hinder skill learning can be seen in an experiment reported by Weinstein and Schmidt (1990). In this experiment, instead of the type of augmented feedback being the problem, which was the case in the previous two examples, the frequency of giving augmented feedback was the problem. Subjects in this experiment practiced
moving a hand-held lever that controlled a cursor on a computer screen. Their goal was to produce a complex wave-form type pattern. Augmented feedback was provided by showing subjects the criterion pattern superimposed on the pattern they produced. One group received this information after every practice trial. A second group experienced what the experimenters called a "faded" schedule of augmented feedback. Fading involved systematically reducing the frequency of trials on which feedback was provided such that by the end of practice, no augmented feedback was being given. Over the course of the 192 practice trials, subjects in this group received augmented feedback on 50% of the trials. The results showed that at the end of practice, both groups were performing similarly. However, after a 1-day rest, both groups were asked to perform the task again but without any augmented feedback. The group that had received feedback on 100% of the practice trials showed a large deterioration in performance on this test, while the 50% group showed only a small decrease in performance. Thus, receiving augmented feedback on every practice trial actually hindered learning compared to what was possible with the feedback given on only half the practice trials.

Two conclusions can be derived from the results from these three experiments. First, there are forms of augmented feedback that can hinder learning. This situation seems to occur when task-intrinsic feedback is not readily apparent to the learner. As a result, the learner develops a dependency on the augmented feedback. The problem with this dependency becomes apparent when the task must be performed at some later time without the augmented information available. Performance suffers greatly in this situation. Dependency on augmented feedback can account for the results in all three experiments. What becomes especially remarkable about the development of this dependency is that it occurred while learning the coincident-anticipation timing task, even though the task could be learned as effectively without augmented feedback as with it. But, because the use of task-intrinsic feedback was not consciously evident to subjects, they were easily misled by erroneous augmented feedback.

Second, it is possible to encourage learners to develop a dependency on augmented feedback by providing this information too often. Because the augmented feedback is easier to use, and typically more meaningful to the learner, the augmented feedback becomes the focus of attention, and important task-intrinsic sensory feedback is ignored. In effect, learners learn the augmented feedback rather than the skill itself. By providing augmented feedback less frequently, the learner is encouraged to also attend to the task-intrinsic feedback and develop performance based on that source of information rather than on the externally presented information. Whether there is an optimal frequency for presenting augmented feedback remains to be determined in future research efforts.

Implications for Skill Instruction

The four different relationships between augmented feedback and motor skill learning indicate that there is more to providing augmented feedback than simply taking a "some is needed" or a "more is better" approach. What we know is that there are skills for which no augmented feedback is needed because
it is redundant information. Also, there are skills for which less augmented feedback is actually better than more. What is important in an instructional situation, then, is to determine what augmented feedback to provide and when to provide it. The preceding discussion of the various relationships between augmented feedback and skill learning provides some direction for making these critical determinations. Three suggestions are presented here.

**Evaluate the Skill**

It is important in any instructional situation to evaluate the augmented feedback needs of the situation as determined by specific characteristics of the skill being taught. Insights into evaluating skill characteristics have been suggested based on those features of skills that have characterized the various effects of augmented feedback on skill learning. At least four features of skills have been described that can be related to the need for or type of augmented feedback for learning the skill. First, if the skill being learned does not allow the learner to detect critical sensory feedback information, such as when a limb’s spatial position cannot be seen, then augmented feedback is required. Second, if the skill being learned involves acquiring a new concept that is essential for successful performance, such as understanding a unit of measurement, then again, augmented feedback is required. Third, if the skill provides the learner with all the essential feedback information needed to learn the skill, then augmented feedback may not be needed. These situations are indeed rare, but they do occur. Fourth, skills for which the outcome is easy to determine but the limb coordination requirements to produce high-level performance are difficult to develop require knowledge of performance about limb movement characteristics. Without this type of augmented feedback, the skill can be learned to a limited degree; however, the availability of augmented feedback based on limb movement characteristics enhances the level of performance achieved. In these situations, what becomes critical to facilitate learning is determining what information to give as augmented feedback and how to give it.

**Evaluate Augmented Feedback Characteristics**

It is important to evaluate the augmented feedback that will be provided in a situation to determine if the feedback may attract the learner’s attention to such an extent that it distracts him or her from essential task-intrinsic feedback such that the learner becomes dependent on the augmented feedback. In the discussion of the experimental examples in which the augmented feedback caused learners to ignore critical sensory feedback and attend exclusively to the augmented feedback, the problem was that such a situation may not be readily apparent because performance during practice, when the augmented feedback is available, is very good. It is only when the skill is performed without the augmented feedback that the dependence on it by the learner becomes evident.

The message here is that the person responsible for designing the instructional conditions must know the skill well enough so that the type of augmented feedback used will not lead to such dependence. The instructor must know how different forms of augmented feedback influence learning a particular skill. Skilled teachers typically use a variety of means to provide augmented feedback. Some
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are verbal, and others are visual. Some methods require another person to provide the information, while others include providing augmented feedback by means of a videotape replay. Some teachers also have students do self-evaluations to compare their performance against a checklist of skill performance characteristics that the teacher has determined to be critical.

In the Winstein and Schmidt (1990) experiment, systematically reducing how often augmented feedback was given eliminated dependency on the augmented feedback and enhanced learning. These results indicate that augmented feedback will be more effective if it is not provided on every practice trial. The advantage of giving augmented feedback less frequently is that the learner is able to engage in some critical self-evaluation of his or her performance. This self-evaluation allows the learner to become more attuned to task-intrinsic feedback and how that relates to what he or she is doing.

One additional point is important to make here. Providing effective augmented feedback clearly requires knowledge of both the skill and augmented feedback. The importance of this knowledge was highlighted in the discussion of the effect of giving erroneous augmented feedback. Even though augmented feedback was not necessary to learn the skill in the experiment by Buekers et al. (1992), the presence of augmented feedback attracted attention to such an extent that incorrect information was not evaluated as incorrect but was used as the basis for performing the skill. What this means is that instructors must provide appropriate information when giving feedback.

Evaluate the Meaningfulness of Augmented Feedback

Augmented feedback is a form of communication to the learner about his or her performance of the skill being learned. It is therefore important to take into account what information will have the most influence on the learner. This assessment of student needs is critical to facilitate skill learning. In fact, a recent study by Tan, Fincher, Manross, Harrington, and Schempp (1994) provides evidence supporting the importance of this type of assessment. They showed that competent teachers with 5 years or more of teaching experience based their instructional activities on regular assessments of students' performance. On the other hand, novice teachers do not show this student-needs assessment characteristic. Teachers seem to acquire this characteristic as they gain experience and become more aware of how to determine instructional strategies that best facilitate skill learning.

Two examples of the importance of meaningfulness of augmented feedback were seen in the research discussed earlier. In the experiment by Wallace and Hagler (1979), verbal encouragement was not as meaningful as information about the component movements of the skill. When knowledge of performance about those movements was provided, learning increased beyond what resulted when only verbal encouragement was given. Similarly, in the experiment by Annett (1959), certain types of augmented feedback were more meaningful than other types. In the case of learning to produce a certain amount of force with a lever, verbal KR about the actual amount of force produced was more meaningful and yielded better learning than seeing a graphic representation of the amount of force being produced while the movement was being produced.
Something alluded to earlier but not discussed is relevant here. The stage of an individual’s learning is also an important learner characteristic for determining what augmented feedback is meaningful (see Magill, 1993). In the discussion of the rhythmic gymnastics rope skill experiment by Magill and Schoenfelder-Zohdi (in press), the type of augmented feedback used was labeled *prescriptive* knowledge of performance. The information given to subjects prescribed what needed to be done to correct an important performance error. If augmented feedback is given to beginners, prescriptive information is important to facilitate learning. This means that the feedback given should contain information that will enable the learner to determine what needs to be done on the next trial to improve performance.

This type of information is distinct from what is known as *descriptive* knowledge of performance, which simply describes the error that must be corrected. For example, telling a person, “Your foot is pointed in the wrong direction,” describes the error that needs correcting but does not give any information about what to do to make the correction. For the beginner, this type of information is of little value. On the other hand, such information can be very useful for the skilled person. Although descriptive KP directs a person’s attention to the error that needs correcting, only the skilled person has the knowledge needed to make the appropriate correction.

**Conclusion**

A critical feature of the communication between instructor and student is the appropriateness of augmented feedback. For some situations, it may be appropriate to give no augmented feedback at all. For other situations, for which augmented feedback is needed, the critical concern must be to determine three things: what information to give, how to give it, and how often to give it. The answers to these important questions should be based on knowledge of the skill being learned, the effects different types of augmented feedback will have on learning that skill, and the characteristics of the individuals learning the skill.

One final point is important to make here. If providing augmented feedback is an evaluation component for determining teacher effectiveness, the frequency of providing feedback should never be the sole criterion. Although important, frequency is not one of the most important aspects of determining the effective use of augmented feedback. This is commonly seen in large classes. The frequency of teacher feedback in these classes is virtually impossible to control. The factor that guides frequency in these situations is the level of performance of individual students. There is much research evidence showing that for large groups, poorer performers typically receive more augmented feedback than others do. Evaluating the augmented feedback component of teacher effectiveness should be done by assessing the appropriateness of the feedback when it is given. The information must be appropriate for the skill being learned, the person learning the skill, and the learning situation.

**References**


