Title
Rate of recalibration: Is learning from verbal feedback equivalent to action practice?

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RATE OF RECALIBRATION: IS LEARNING FROM VERBAL FEEDBACK EQUIVALENT TO ACTION PRACTICE?

By

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Abstract

Prior work on recalibration—adapting decisions to account for changes in body size—shows that accuracy depends on experience (Franchak & Adolph, 2014). Specifically, both motor practice of fitting through a doorway and verbal feedback about accuracy improve an observer's ability to make accurate judgments (Franchak, in press). Because recalibration was similar for motor practice and verbal feedback, it is unclear whether these experiences represent two distinct processes or a single process. To test this, we compared the rate of learning and retention of learning between these two types of experiences.

In the current study, an adjustable doorway apparatus was used to measure participants' perceptual judgments of the smallest doorway they could fit through while wearing a backpack. Participants completed 24 judgment trials before receiving either motor experience or verbal feedback. In the motor practice condition, participants attempted to fit through 20 different sized doorways. In the verbal feedback condition, participants provided yes/no responses about whether they believe they could fit through 20 different sized doorways and the experimenter informed them if they were correct or incorrect. In both conditions, 4 judgments trials were completed after every 5 motor practice/verbal feedback trials to determine how quickly they recalibrated for each learning method. Upon completing the learning trials, participants sat at a computer to do an unrelated task for 5 minutes. Afterwards, participants completed a final set of judgments in order to determine how well learning was retained in each condition.

The findings showed that learning did not occur without experience in either condition (i.e., during the 24 judgment trials prior to experience). These results would

further support the notion that experience is necessary in order to recalibrate to a change in body size. Furthermore, motor practice and verbal feedback conditions both effectively retained learned affordances after distractor tasks. Lastly, recalibration occurred rapidly and at a consistent rate between both conditions; however, recalibration consistently regressed after the 2nd experience trial.

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Individuals develop a sense of self-awareness of their physical capabilities through a variety of exploratory behaviors. Understanding ones affordance within a particular environment can be induced through experience within an environment. Affordance is identified as all possible actions one can engage in within his or her environment (Gibson 1979, Warren 1984). Affordance pinpoints the options one may choose when interacting with the environment, but perceiving affordance attempts to separate these interactions into two categories: possible and impossible. One's perception of their individual affordance helps dictate the success rate of performing an action in their surroundings based on their physical capabilities, which can be a difficult task.

When changes within our environment are altered, ones affordance is then changed. In order for someone to adjust their perceived affordance they must interact with the environment in effort to prompt recalibration. Recalibrating oneself with the surrounding environment will help someone identify their affordance thresholds for specific actions. Affordance thresholds are the limit of one's ability to complete a task within the environment. Since our environment is always changing we find ourselves constantly recalibrating through experience. Recalibration can be done successfully for different types of tasks based on different types of experiences.

Exploratory actions are one's actions within their environment that helps develop one's sense of affordance within a specific environment. Exploratory actions seek to obtain information about the environment, while performatory actions seek to complete a task. With some tasks being both exploratory and performatory, one cannot label them as mutually exclusive. Different types of exploratory actions must be conducted in order to understand which specific actions induce a specific type of learning within the environment. With everyone possessing some idea of their affordance threshold, placing them in an environment after altering a constant, such as body size, can be seen as challenging their perception of affordance and requiring exploratory actions to recalibrate; however, not all exploratory actions are equal.

Different exploratory actions provide varying levels of learning and recalibration. Perceptual-motor exploration can be achieved by a variation of activities, such as throwing (Zhu & Bingham, 2010), passing through doorways (Franchak, in press; Faith & Fajen, 2011) passage under barriers (Franchak, Celano, & Adolph, 2012) and sitting (Mark, 87). However, even though some used practice as a method for recalibration, it is not always required. For example, in Mark (1987), participants were to attempt a sitting and reach task while standing on blocks to alter height dimensions. These participants were able to recalibrate with no practice or walking on blocks experience and improved at a steady rate across the trials. In addition, Stoffregen and colleagues (2005) replicated Mark and colleagues (1990), which suggested that no practice was required, but other information was sought out. Stoffregen and colleagues (2005) challenged the notion that sway was simply "noise" for recalibration; however, he concluded that sway is related to an increase in judgment accuracy, thus gradually generates information necessary for recalibration without practice. Although, these tasks allowed for recalibration to occur with no practice, not every task can induce recalibrate in that manner.

Franchak (in press) tested number of different exploratory actions, including: squeezing through a doorway, squeezing through a doorway with no visual input and pressing against a wall. Squeezing through a doorway condition increased participants understanding of personal affordance, while the later conditions failed to do so. Although some exploratory and performatory actions increase learning, one is able to learn their affordance without motor practice (Mark 1887, Mark 1890, Stoffregen 2005), and by simply being told the information exploration is trying to obtain. Perceptual-motor exploration with no visual input is not sufficient for recalibration, suggesting practice entails a different variety of information, leading to the comparison of perceptual-motor experiences to verbal feedback.

Recalibration is possible without exploring if the information generated through exploration is simply provided. With visual inputs being necessary for accurate affordance perception (Stoffregen et al., 2009) it is necessary for recalibration. In motor practice, visual information establishes what doorways are possible vs. impossible, while in verbal feedback the visual information provides the same information to recalibrate without actually using exploratory actions. In Franchak (in press), they had participants pass through a doorway and presented a "feedback" condition that provided affordance information with no exploration or performatory action, which led to learning and recalibration. With studies identifying which exploratory actions proved sufficient for learning, they never sought to identify which was the optimal and most efficient method of learning for their specific domain.

With specific types of practice and experiences promoting feedback, we begin to question if there are differences between the rate of learning or if all recalibration tasks produce equal levels of learning. With both practice and no practice conditions, showing significant improvement in perceived affordance, our experiment sought to breakdown the recalibration process into segments and compare across conditions to identify any possible differences in the rate of learning. By breaking up experiences into short increments of five motor practice or verbal feedback conditions, we can identify recalibration rates more precisely within and between conditions.

Current Study

The current study asked to what extent learning from motor practice and verbal feedback are equivalent. To test this, we compared whether people who experience motor practice and verbal feedback learned at different rates and retained learning after a delay. There are two different possible outcomes. First, the rate of learning for both motor practice and verbal feedback are equivalent and retained equally well because only knowledge of results from motor practice is used for learning. The second possible outcome is that motor practice and verbal feedback induce learning at different rates, but learning remains retained. If rates of learning prove to be different, it would infer that learning is not simply dependent on information generated from practice.

We tested learning in response to changes in abilities for fitting through doorways. To create a need for learning, we asked participants to judge whether they could fit through doorways of different size while wearing a backpack that altered their body dimensions. The participants were provided with different types of experience and performed repeated judgments showing how perception changes after receiving different amounts of experience. We compared judgments after varying amounts of either motor practice or verbal feedback. In the motor practice condition, participants walked through doorways of different sizes. In the verbal feedback condition, participants provided verbal judgments about their abilities of passing doorway openings while the experimenter provided feedback. Finally, we tested retention by providing a distracter task for 5 minutes then having participants provide their judgments again.

To assess the accuracy of judgments, we compared judgments to true affordances. We measured affordances by having participants walk through doorways of different sizes to record if participants successfully passed through or got stuck (Franchak, in press) to determine the smallest doorway that was possible to fit through. Based on prior work, we predict there will be no improvement prior to experience, while accuracy of affordance judgments will improve after both types of experiences (Franchak, in press). If motor practice and verbal feedback are equivalent, then learning should remain constant between both motor practice and verbal feedback, while learning is retained. If outcome two occurs, then practice is not required for learning to occur and may occur through simple observations.

Method

Participants

Fifty university undergraduates participated in the study (nineteen males and thirty-one females. The age range of our participants was seventeen years old to twenty – two years old (*M* = 19.86). The undergraduates were all from the University of California, Riverside and participated in the study for course credit. Participants were assigned to either the motor practice or verbal feedback condition.

Apparatus

Participants walked through a doorway (67.5 cm wide x 208.6 cm high) with sliding wall that can be adjusted in 0.1-cm increments to create doorways ranging from 0-67.5 cm in width. The sliding wall presses against a perpendicular, stationary wall, which is 61 cm wide x 208.6 cm high. During affordance measurement trails participants started 45.7 cm away from the doorway; however, during the judgment and experience trials, the participants started each trial 350.5 cm from the doorway. A camera was mounted on the back of the door which pointed to the measuring tape on the apparatus which was displayed on a screen to determine how wide the doorway was at any given moment. To prevent participants from making points of reference to measure doorway size, the wall behind the doorway was covered with white paper.

Procedure

Participants started by putting on backpack in order to alter their body dimensions. Then we tested affordance in order to retrieve the participant's threshold. Once the threshold has been obtained we conducted 24 judgments prior to experience trials. Afterwards, participants completed 5 experience trials followed by 4 post experience judgments, which was repeated 4 times. A distractor task was then conducted, followed by 4 retention judgments. The participant's height and weight are recorded. The entire session lasts ~45 minute.

Affordance measurement trials. Affordance reflects the participant's actual ability to pass through the doorway. We defined affordance thresholds as the smallest doorway the participant can squeeze through without getting stuck. Affordance thresholds served two purposes. First, affordance thresholds serve as a point of reference when comparing the level of accuracy in participant's judgments. Second, by obtaining affordance thresholds at the beginning of the session, we are able to give accurate feedback in the feedback condition. However, passing through the doorway would subject participants to learning. Luckily, learning is absent without visual stimulation (Franchak, in press); therefore, by having the participants pass with their eyes closed, learning will be absent.

To obtain affordance, we conducted 15 trials that inhibited the participant's vision. By having the participants close their eye, we can ensure no learning will occur on account of vision, since vision is necessary for learning. Participants were instructed to stand 45.7 cm away from the doorway with their eyes closed. We used a stair-casing model to generate doorway sizes. The participant was to then attempt to pass through the doorway with their eyes remaining closed. When participants successfully passed or failed to pass, the doorway was fully opened and the participants were instructed to resume the start position. This was repeated until 15 trials were completed.

Judgment trials. Pre experience judgments, post experience judgments and retention all used the method of limits to assess accuracy of judgments. The method of limits is when a stimulus can increase or decrease in intensity at a consistent rate for participants to make perceived judgments. For this experiment, we used the method of limits with ascending and descending doorways, when having the participants make judgments. By using both ascending and descending doorways we can help eliminate any differential thresholds with a specific direction of change. A doorway is classified as ascending when it begins at the closed position and gradually opens towards the widest position. A descending doorway is when the doorway begins at its widest position and gradually closes to the closed position. In pretest, posttest and retention, participants were instructed to stand 8 feet from the doorway, which was marked by a line of tape. The researcher then used the method of limits when slowly opening and closing the doorway. The participant then said, "stop" at the smallest doorway they believe they could squeeze through. The participant was allowed to adjust the doorway to a more exact size and said, "final" to finalize their judgment. Pretest was used first to determine the baseline level of accuracy we’ll be comparing posttest judgments to. Posttest judgments were included between 5 experience trials to examine the rate at which learning occurred. Lastly, retention used 4 judgments to determine if learning was retained over a 5-minute delay.

Experience trials. Participants were placed into two conditions, which determined their type of experience: motor experience or verbal feedback. Motor experience had the participants to attempt to pass through the doorway. Verbal feedback had participants verbally indicate their perceived ability of passing through the presented doorway. Participants were instructed to stand 8 feet from the doorway, which was labeled by a line of tape. They were to face away from the doorway, until the doorway had been properly adjusted for each trial. The researcher would then have the participant face the doorway. If in the motor condition the participant would then attempt to pass through the doorway. If in the verbal condition, the participant would state if they believe they can successfully pass or not. After each judgment, the researcher will inform the participant of the correct answer, which is based of their affordance threshold. A total of 20 experience trials were conducted, in increments of 5, which preceded judgment trials

Distractor task. The distractor task was an online computer game known as Unblock Me (OnlineGamesBazar.com). The objective of the game is to move the surrounding brown blocks in order for the red block to pass through an opening. The participants are given a paragraph, which summarized the objective of the game and a short video clip of the game being performed, so they understand how to play. The participant is given 5 minutes to complete and reach the highest level possible.

Data processing

Affordance threshold is the smallest doorway the participant can fit through one any trial. In order to calculate judgment errors we calculated the absolute values of the difference between judgments and affordance thresholds for each participant. By taking the errors and averaging them within each phase, we were able to determine the different rate of recalibration. With each phase, judgment trial, following experience trials, phases vary based on how much experience the participant has gains and is compared to the errors established from the receding phase to determine differences in perceived affordance from phase to phase.

Results

The main questions this study sought to find was if different types of experience (motor vs. verbal) induced a different rate of learning when passing through a doorway and if learning is retained. In order to pin point where learning is occurring we conducted a 2x7 ANOVA to determine the error between each phase. Error can be calculated by comparing the judgment trials, which analyzed the participant's perceived affordance, to their actual affordance. We also looked for the main effect sizes of both: condition and phase. The seven phases in this experiment are: PRE1, PRE2, POST1, POST2, POST3, POST4 and RET. PRE1 is the average of the first 4 perceived affordance judgments prior to any experience. PRE2 is the average of the last 4 perceived affordance judgments prior to any experience. POST1 is the average of four judgments after the first set of 5 experience trials. POST2 is the average of four judgments after the second set of 5 experience trials. POST3 is the average of four judgments after the third set of 5 experience trials. POST4 is the average of four judgments after the fourth set of 5 experience trials. RET is the average of ones perceived affordance judgments after a 5 minute distractor task. As seen in Figure 1, perceived affordance judgments after some level of experience were broken up into segments to evaluate the rate of learning, the POST1-4 displayed above are the phase we used to measured learning progress after experience trials. Figure 1 shows there were no main effects of condition, $F(1, 48) = 0.015$, $p = .904$, however, a there is a significant main effect of phase, $F(6,288) = 4.26$, $p < .001$). In addition, we note that there was no phase and condition interaction, $F(6,288) = 1.33$, $p = .242$, indicating phase was not affected by condition. The main effect of phase indicates that learning did not occur at consistent rates throughout each phase.

In order to test if participants learned over all the blocks we analyzed differences between PRE1-2 ($M = 4.15$, $SD = 2.635$) and POST1-4 ($M = 3.11$, $SD = 1.720$). There proved to be a significant difference between the two, indicating that participants learned from experience, $F(1,48) = 8.20$, $p = .006$. In addition, ensuring learning did not take place simply through PRE1-2, we tested PRE1 to PRE2, showing there was no significant difference between the two, indicating that learning did not take place in the absence of experience for both the practice and feedback conditions, $F(1,48) = .115$, $p = .736$. With learning having occurred based on the averages of POST1-4, we would like to identify if all 4-post blocks were required for learning. We then decided to analyze PRE2 to POST1, which showed a significant difference $F(1,48) = 15.26$, $p < .001$. This indication of rapid learning displayed how 5 experience trials are sufficient for learning. As post experience data is collected, one might ask if learning continues throughout the stages, so we tested linear change during post experience trials (POST1-4). Although the initial POST1 induced learning, a linear change throughout POST1-4 (Figure 1) was significant, alluding to a slight decrease of accuracy after the initial POST1 block.

Since learning occurred over POST1-4 trials, analyzing retention was critical in determining if improved estimation were in fact due to learning or by memorization /familiarization of the doorway. By comparing last block of post-test (M = 3.58, SD = 2.46) to the retention block (M = 3.73, SD = 2.995), the difference between both showed to be not significant, implying that whatever learning occurs after experience is retained, $F(1,48) = .244$, $p = .624$.

The results of this experiment exhibit failed to find differences in the process of learning between the conditions of motor experience and verbal feedback. While differences may not exist between the conditions, they do exist within condition, through the main effect of phase. With retention not holding a significant difference, learning about passing through a doorway can be viewed as retainable information that can be learned after 5 experience trials.

Discussion

The current study asked to what extent recalibration from motor practice and verbal feedback are equivalent by measuring the rate of learning and retention. With different forms of experience being conducted (motor practice and verbal feedback) we were able to replicate the results from (Franchak, in press) indicating that both motor practice and verbal feedback successfully recalibrated participants. Along with replicating these results, we were able to show that recalibration occurred rapidly and was retained over a five-minute delay. Following the rapid recalibration in both motor experience and verbal feedback, perceived affordance gradually got worse in both conditions. Both conditions displayed similar recalibration rates throughout the phases.

Study replication and extensions

Our current study, sought to expand on the findings in Franchak (in press) by shifting our attention to the rate of recalibration and retention with verbal feedback and motor practice. In past work (Franchak, in press), recalibration was observed in perceived affordances across both motor experience and verbal feedback after 20 consecutive experience trials; the results were replicated in the current study. We extend past work by breaking up those 20 experience trials into increments of 5 to examine the rate of learning and including a delay task after those 20 experience trials to test retention. When comparing the two studies, it is evident that our PRE1-2 errors are smaller in comparison. Indicating that both studies found decreases in judgment errors from PRE1-2 to POST1-4; however, the decrease in error was smaller in the current study. Why did this shift in POST1-2 effect occur? One conclusion is the use of a different method to present doorway sizes. In Franchak (in press) the doorway sizes were generated using a stair casing model, which stated at 40cm. When a participant guessed if they could pass through the doorway, the door closed 2 cm, when the participant perceived they could not pass the doorway opened 1.5 cm. The doorway usually averaged out to the participant's actual affordance towards the end of pretest, which was obtained at the end of the study. In our current study, we used the method of limits, which when we use ascending and descending doors participants make judgments. The difference between Franchak (in press) having a systematic method of door selection based on participants received affordance and a more fluid approach of having participants consistently provide the doorway size ask their perceived affordance, may have driven pretest errors in the current study. Another conclusion is the use of blind trials. In Franchak (in press), actual affordance was obtained after all experience and posttest has been completed, since actual affordance was not required to generate door sizes. In our current study, actual affordance was required when generating specific doorway sizes, thus requiring us to conduct a blind trial before pretest. In Franchak (in press), blind trials were not sufficient for recalibration; however, there was an insignificant trend of decreases in perceived affordances, which might explain why the current study obtained smaller pretest judgments.

Rapid recalibration

Current findings extend past work by showing that learning was rapid. Franchak (in press) demonstrated that participants learned by the end of 20 trials, but it was unclear how much experience was needed to learn. By separating experiences tasks into four segments, we were able to show that rapid recalibration occurred after just the first four experience trials. With prior work showing that recalibration occurs gradually, like Mark (1987), which showed recalibration through eye-height scaling at a much slower rate, the rapid recalibration in the doorway domain was unanticipated. A reason for this recalibration to occur right after experience might be due to the size in the potential for learning. Participants' perceived affordances were about 6 cm off their actual affordance providing a lot of room for recalibration to occur. After the participants first experience trial, they become aware that their error is large then moved drastically to reduce that obvious error. After this rapid shift of perceived affordance in the direction of actual affordance, the error between perceived affordance and actual affordance is not as obvious, which led to the perceived affordance to fall back closer to set point, which is the pretest perceived affordance. When comparing the current study to Mark (1990), their recalibration rate proved to be more gradual which may be due to the stair casing model used. With judgments starting at a larger distance from set point the accuracy of judgments will increase. The judgment conditions will then gradually move towards the participant's actual affordance leading to gradual recalibration.

Regression in recalibration

Once rapid recalibration occurred after the POST1, the rate of learning got consistently worse between POST2-4. The gradual shift of increased error over POST 2-4 is surprising; however, it can be explained. It's possible that since the size in error was large enough, participants had more of an opportunity to recalibrate. With such a large error, participants are provided a greater window for recalibrations so when experience trials occur, they recognize how far from actual affordance they really are and rapidly improve in judgments. The participant might have initially understood their judgments were very inaccurate, thus making a dramatic shift in perceived affordance through judgment trials. Since that shift in judgment is significantly closer to their actual affordance, the potential for more learning is significantly smaller, leading to smaller changes in perceived affordance from POST2-4. That drastic shift in perceived affordance can be seen as their maximum potential for learning, with the gradual shift to worse results is simply the participant averaging out what they learned. Essentially, after the first experience trial the participants know they are very inaccurate and the direction of the error, so they make a dramatic improvement towards actual affordance, meaning they did not learn their actual affordance, but the error size. Once the size of the error is smaller, they begin to show what their recalibration truly is.

Vision component

With motor practice and verbal feedback, using different methods of stimuli for learning, one would think the rate or learning might be inconsistent with one another and that one might be more effective in terms of recalibration rates. With two types of experiences driving recalibration, we need to ask: Why was recalibration similar for the two different types of experience? One possible reason, is that visual input is important for recalibration. With the only difference between motor practice and no-vision trials being sight, visual information appears hold a key component to recalibration (Franchak, in press). The pairing of vision with some type of knowledge about one's actual affordance, appears to drive recalibration. Although, vision is a significant aspect, it cannot stand as the sole reason for recalibration.

Possible vs. impossible

In addition, one may see that the method in which someone learns possible vs. impossible is not important, but what remains important is simply possessing some basic knowledge of actual affordance. In motor practice and verbal feedback, participants are provided knowledge about their body's actual affordance through verbal means or engaging with the doorway. Either way, the important of possible vs. impossible is provided. Therefore, relaying on visual information to assess the doorway size in question, while receiving some basic knowledge on possible vs. impossible is enough to recalibrate. As long as those two inputs are being generated, then the participant will recalibrate in the same manner, as seen in both motor practice and verbal feedback.

Future studies

With both motor practice and verbal feedback possessing the same rates of learning for each posttest, our speculation that visual information and knowledge about possible vs. impossible is enough for recalibration must be given more attention. Since experiencing possible vs. impossible doorways is necessary for recalibration, it would be interesting if we provide false information to participants about successes and failures. The false affordance information will be separated into 2 conditions: above actual affordance or below actual affordance. In this study we will like to identify if we can replicate the learning trend in our current study in both condition. Its important to note, that we would only be able to use the verbal feedback condition, since one can not manipulate actual affordance in motor practice; however, since the learning trends are almost exact between the two conditions, only using verbal feedback will be sufficient. Another possible expansion from the current study is to utilize the no-vision manipulation after the participant receives visual information. The participant will be able to view the doorway from an established distance; however, the participant must squeeze through the doorway with their eye closed. This will help us determine if vision is essential for learning when conducting the squeezing action, or if viewing the doorway from a distance prior to the no vision action is sufficient for recalibration.

While thinking about future studies, we must reflect on how our current study could have improved. For instance, we might want to look at how we can establish constant rate for ascending and descending doorway sizes. We do not know how sensitive participants are to the speed of the doorway. We addressed this by allowing the participant to adjust the doorway with minute changes and finalize the selected doorway.

Conclusion

Through our expansion from the Franchak (in press) study, we not only replicated the results of effective recalibration for both motor practice and verbal feedback, but also identified the rate of recalibration and if that information was retained. Participants were able to successfully retain information and displayed rapid levels of recalibration in both conditions with gradual regression. With participants becoming worse after rapid recalibration, we need to explore this unusual characteristic of learning more thoroughly. With the hypothesis that information requires visual input and true affordance information to determine possible vs. impossible, we still need to learn if trends found in our study can be replicated with false actual affordance and how that information affects perceived affordance.

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Appendix

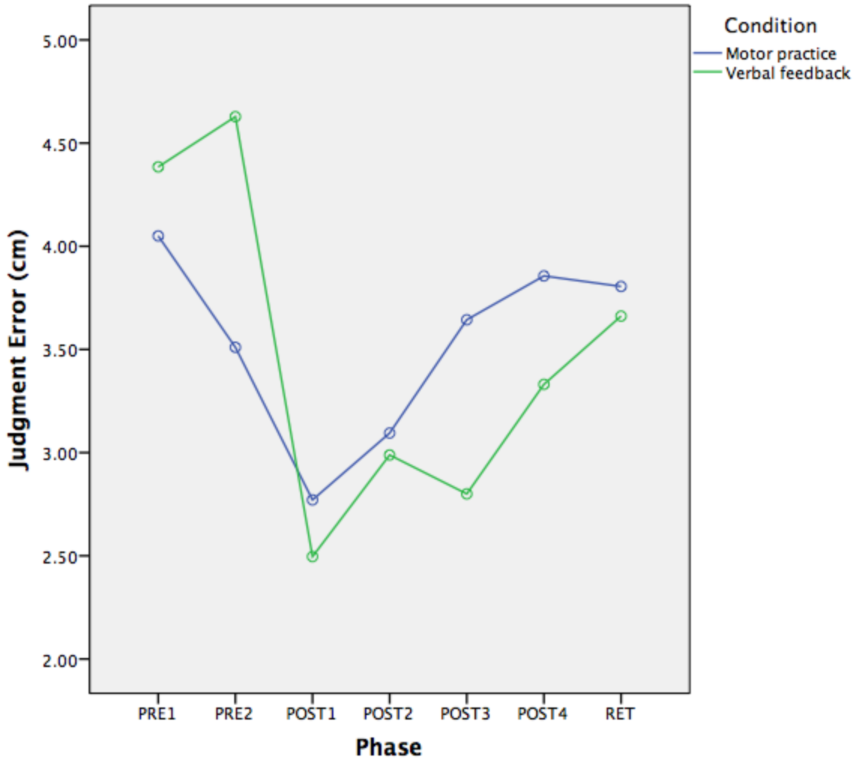

Figure 1. Averages of perceived affordance in relation to actual affordance, between condition and phase