What we think we learn from watching others: The moderating role of ability on perceptions of learning from observation.

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Abstract

Despite increased interest in the processes guiding action observation and observational learning we know little about what people think they learn from watching, how well perceptions of learning marry with actual ability and how ability perceptions develop across multiple observation trials. We conducted two studies that were designed to evaluate the observational learning process and to probe how demonstrations influence actual ability as well as perceptions of ability. The general methods involved repeated observation of a 2-ball juggling task. After each video observation, observers were asked to report if they thought they could perform the skill, along with a confidence score (0-100%). In Experiment 1, an Observe-only group was compared to an Observe + Physical practice and No-practice group. Both observer groups showed a better physical approximation of the juggling action after practice and in retention and their confidence gradually increased. In Experiment 2, we limited physical practice to 5 attempts (across 50 observation trials). In general, people who had high perceptions of ability following a demonstration were overconfident, whereas those with lower perceptions of ability were accurate in their assessments. Confidence generally increased across practice, particularly for trials following observation rather than physical practice. We conclude that observational practice increases people's confidence in their ability to perform a skill, even despite physical experiences to the contrary, and that these increases are initially quite gradual and incremental.

Probing how we learn and what we think we learn from observational practice of a novel action

In studies of observational learning, the focus of research has been on ascertaining what people learn from watching others. That is, how well are people able to perform a skill after watching and what changes occur behaviourally and more recently, at a cortical level. Little attention has been paid to the question of what people think they are learning from watching and how perceptions of ability as a result of watching match physical performance. Because practice attempts are typically needed to make conclusions about performance, it has been difficult to describe how the observational practice process proceeds, uncontaminated from physical practice. Perceptions of learning, however, can be ascertained in the absence of practice attempts and can thus potentially provide a metric of acquisition and inform about the gradual or more discontinuous nature of this observation process.

Watching someone else perform a skill offers a potential wealth of information to a beginner. Uncovering what this information is and when it is used is important to aid our understanding of the observational practice process. There have been attempts to manipulate information within displays to ascertain the type of information extracted from a dynamic display (e.g., Scully and Newell 1985; Hodges, et al. 2007) and there have also been empirical studies designed to test the knowledge gained from action observation (e.g., Bird and Heyes 2005; Ong et al. 2011). However, no attempt has been made to tie this development of knowledge, to perceptions of ability and actual motor ability. Because there is evidence that at a cortical level, action-observation processes are dependent on the motor skills of the observer (e.g., Calvo-Merino et al. 2005, 2006), such that motor simulation of an action requires action experience, the process of how we learn novel skills through watching still requires explanation beyond simply a low-level copying.

It has been suggested that demonstrations provide goal-related information that help guide practice in the form of a reference (e.g., Adams 1971, 1986; Caroll and Bandura, 1982, 1985, 1990). This reference allows the learner to compare their own attempts and arguably form conceptions of ability. In the absence of physical practice, it is unknown whether this conception of ability changes with repeated observations. We know that the quality of the representation of the action changes (at least for simple, serial actions, Carroll and Bandura 1990), but there is little understanding as to how observational practice proceeds in the absence of physical practice attempts and how well conceptions of ability match actual skill performance.

It is a commonly held belief that the acquisition of skills occurs gradually over a period of practice and can be best described as exponential (i.e., a monotonically decreasing improvement, e.g., Crossman 1959; Heathcote et al. 2000). Yet, there is also evidence to suggest that motor skill learning is discontinuous in nature, such that learners experience a sudden change in their level of performance, instigated by a change in strategic knowledge or 'insight' (Aziz-Zadeh et al.2009). This shift in ability is characterized first by a number of unsuccessful attempts, with seemingly no change in performance, followed by a sudden onset of stable, correctly performed attempts (see Dickinson et al. 2004). This 'one-trial' acquisition was initially studied in the verbal learning domain by Rock (1957), but has since been replicated in a paired-associate design involving simple hand actions (Randall et al. 1995). For the learning of more complex motor skills, that require the integration of different limbs, research evidence is mixed with respect to how learning progresses (e.g., Anderson 2000; Randall 1999).

Self-efficacy beliefs (i.e., self-belief in ability to later successfully perform an action) have repeatedly been shown to predict actual success (e.g., Bandura 1977, 1994). Recently, there has been a growing amount of evidence that people's beliefs affect how they learn and retain skills. For example, beliefs concerning whether a skill is more or less acquirable through practice dictates subsequent performance, motivation and the amount of practice participants are prepared to devote to improving performance (see Dweck 2006 for a review). This was recently demonstrated in a motor learning task whereby people who thought that a skill was learnable, as opposed to reflective of fixed ability, showed improved learning (Wulf and Lewthwaite 2009). Importantly, this research shows that perceptions of ability (and learnability) matter for actual learning and real behavioural improvements.

Despite evidence of congruence between ability perceptions and actual ability, there is also evidence that perceptions of ability are not well matched to actual ability, particularly among novice performers (Dunning 2011). This has been referred to as the Dunning-Kruger effect, based on the authors who conducted the first studies to show that incompetent performers show poor metacognitive awareness of their actual ability on an absolute scale as well as relative to others (Kruger and Dunning 1999). This research and associated effects has mostly been limited to cognitive/ knowledge-based tasks and not to performance and learning of motor skills.

If we are able to show that people believe they have learnt from watching, irrespective of whether they do, then arguably this would be a positive endorsement of the observational practice process, not least because we would expect perceptions of ability to impact on subsequent investments of time and effort into practice (see Bandura 1994; Wulf and Lewthwaite 2009). However, the amount or type of information people seek from a demonstration may be affected by their belief as to whether or not and to what degree they have learnt from watching, thus functioning in a potentially negative fashion. Therefore, it is important to gauge the coupling between perceptions and actual learning and to determine potential benefits of observational practice, beyond immediate performance improvements.

The objectives of our current investigations were two-fold. First, we wished to know whether observers think they learn from watching, what information potentially guides this perception and if and how conceptions of ability change with repeated observations. Second, we were interested in the accuracy of this knowledge with respect to actual capability to perform an observed skill. To answer these questions, we used a two-ball juggling task because of its novelty and difficultly to perform without physical practice. In comparison to 3 ball juggling however, 2-ball juggling can be acquired in a relatively short amount of time. It has also been suggested that spatial-temporal tasks might lend well to the one-trial phenomenon where success and failure are more readily distinguished (Dickinson et al. 2004). It is also known that the two-ball juggling task can be defined by an explicit, verbalizable strategy (i.e., “throw-throw, catch-catch”) that might allow for insights to develop through observation. We ascertained perceptions of learning and strategic insights through three methods. We asked for discrete judgments of beliefs in ability, confidence ratings that allowed for sensitivity in detecting perceptions of learning and direct questioning regarding knowledge acquired through watching.

In a first experiment, we compared ability perceptions of two observation groups (one with and one without physical practice; recently referred to in the literature as observational learning and observational practice respectively, Vogt and Thomaschke 2007). We then assessed how well these individuals performed on tests of immediate and delayed retention in comparison to a no-observational practice group. We predicted that the two practice groups would outperform the control group and that the physical practice group would be best. With respect to our study aims, if observational practice enhances conceptions of ability, then ratings of ability and confidence should increase during repeated observations.

If these conceptions change then we were interested to see whether this was best defined as incremental or discontinuous, potentially defined by jumps in perceptions of ability alongside insights about how to perform the skill.

If observation of a novel motor task informs the learner's metacognitive awareness of their own ability, then we expected that participants would have accurate insight into their motor competence such that those reporting higher confidence in their ability would succeed at the task more frequently than those with lower confidence. This latter question was directly examined in a second experiment where we compared the actual motor ability of participants once they reported that they were able to perform the juggling action with high confidence ("High perceived-ability group"). These individuals were yoked to another group who did not have high ability ratings after the same number of observation trials ("Low perceived-ability group"). We predicted that participants with high perceptions of ability would be more successful than participants matched at the same time point. Incidentally, we were also able to study how perceptions of success changed in the presence of feedback alerting to actual ability (either success or failure) and hence test the idea that perceptions of competence, even after failure, might be resistant to change (i.e., Dunning-Kruger effect).

Experiment 1

Methods

Participants and groups

Thirty-six university students participated and were pseudo-randomly assigned to one of three groups; Observation-only, Observation + Physical practice (PP) and a no-practice, Control group (n=12/gp, 6-8 females/gp, *M* age =23 yr, range = 18-35 yr). The Observation + PP group was assigned last. Participants were recruited based on self-report of having no previous experience with juggling.

Task and apparatus

Participants were asked to observe a two-ball juggling action referred to as the exchange juggling task (Zentgraf and Munzert 2009). This action is often used as a prerequisite for learning the three-ball cascade juggle because it includes similar characteristics, yet is less complex. The action is terminated after only one cycle and it involves only 2 balls. The task begins with a ball in each hand and is initiated by tossing the ball in the dominant hand to the contralateral hand such that each ball follows a parabolic trajectory. As in the cascade juggle, the second ball should be released once the first ball reaches its zenith (Beek 1989). The exchange juggle task is terminated once both balls are caught. For our purposes, a successful juggle was defined as two temporally asymmetrical tosses and catches, where both balls are in the air at the same time, and each ball is caught in the opposite hand.

Participants were positioned in front of a full, body-size (120”) projector screen (Cineplex Pro, IN, U.S.A) onto which a video of a skilled model was displayed. One full cycle of the 2-ball juggling action was shown from a 3rd person perspective (i.e. mirrored image) and included the entire body of the skilled juggler as well as the flight of the balls. The participants’ physical attempts were recorded using a Panasonic video camera to allow a more fine-grained scoring of juggling quality.

Procedures

This experiment consisted of one pre-test trial, a 50 trial practice phase and two, 5 trial, immediate and delayed (24 hour) retention tests of the 2-ball juggling action. Participants in the 3 groups completed all phases of the experiment, except for the Control group who did not practice. A one-trial pretest was included to ensure that participants were indeed novice at (2-ball) juggling, but it was limited to allow us to assess perceptions of learning uncontaminated by physical practice and feedback about ability. Participants were given brief instructions outlining the goal of the action (i.e., that the 2 balls were to be thrown into the air and caught by the opposite hand).

During practice, the two observational practice groups watched 50 video recordings of the same skilled model perform the same 2-ball juggling action. After each trial, participants were asked to self-report on their perceived ability to juggle the 2 balls (forced ‘yes’ or ‘no’ response), their associated confidence in being able to juggle (from 0, not at all confident to 100% confident), and any information about how to juggle that they had gained from watching. The Observation group did not receive any physical practice, whereas the Observation + PP group was allowed one attempt after watching each video. At the end of the 50 observation trials and following a 2 minute rest (or approximately a 20 min interval spent outside of the lab. for the Control group), participants completed an immediate retention test. This consisted of 5 physical attempts where success was recorded. The groups returned to the lab. the following day where they completed 5 further trials in a delayed retention test.

Data analysis

Behavioural outcomes

For the immediate and delayed retention tests we calculated a mean proportion success score for each person based on the 5 throws at each phase (where 1 = perfect score). These data were analyzed in a 3 Group x 2 Test (IR/DR) repeated measures (RM) ANOVA. Because we had 2 experimental and one control group and specific predictions relating to these 3 groups, group effects were analyzed with pre-planned orthogonal contrasts enabling comparisons of; (i) the Control group to the two practice groups (i.e., Observe-only and Observer + PP), as well as (ii) comparison of these two latter observation groups. This analysis negated the need for low power, post-hoc tests. Significant effects involving more than 2 means based on repeated measures factors were followed up with Tukey HSD analysis ($p<.05$). Greenhouse-Geisser corrections to df were applied to sphericity violations.

We performed secondary analyses on video data to score the juggle based on 3 criteria related to the success of the throws and catches. Two points were awarded if the balls were; i) released at different times (i.e., asymmetrical release) of ~.5 s or more between hands (>14 frames), 1 point if there was some asymmetry (< .5 s, or between 6-13 frames) and 0 points for symmetrical ball release. Two points were also awarded if; ii) the peak height of both balls was approximately equivalent, 1 point if they were noticeably different and 0 points were given if one ball was transferred, rather than thrown to the opposite hand. Finally, 2 points were awarded for; iii) a successful catch of each ball in the opposite hand, 1 point for a successful catch by one hand, and 0 points if the balls were not caught. This resulted in a total score of 6 for a successful 2-ball juggle. All videos were rated by the same individual following evidence that the scoring was objective. This evidence was based on an independent analysis of two participants from each group who were chosen at random (n = 6). The single-rater intra-class correlation was very high (.99).

The video data were analyzed two ways. To determine whether performance had improved since the one trial pre-test, we compared the means for IR and DR to the pre-test score in a 3 Group x 3 Time (pre, IR, DR) RM ANOVA (with contrasts and post hocs as detailed above). To determine whether proficiency improved with practice attempts across the IR and DR tests we ran the same RM ANOVA with just the retention tests, now including Trial as a third factor (with 5 levels).

Confidence

To determine if participants believed themselves to be learning during observational practice, and how, we analyzed the confidence ratings of the Observe-only group and compared these to the Observe +PP group. We first compared the confidence ratings summed across each block of 5 trials in a 2 Group x 5 Block RM ANOVA (with post hocs as above). We then plotted confidence graphs for all the participants and characterized confidence curves as either incremental or sudden, with the latter designation when confidence increased by more than 20 % across successive trials.

Partial eta squared values (η_p^2) are reported as measures of effect size for all statistically significant effects based on ANOVA, Cohen's *d* is given for t-tests and power values (1-ß) are given for non-statistically significant effects where F>1.

Results

1. Observers learn from watching

Ten out of twelve (83%) of both the Observe-only group and the Observe +PP group were able to perform at least one successful juggle in the immediate retention (IR) test, in comparison to n = 7 (58%) in the Control group. In delayed retention this dropped to n = 5 for the Control group (42%), n = 9 (75%) for the Observe + PP group and remained at n = 10 for the Observe-only group.

Analysis of the accuracy means (i.e., proportion of successful juggles) for IR and DR did not, however, yield significant group differences (Control vs. Observe-only and Obs+PP, $p = .15$, difference = .17; Observe-only vs. Obs+PP, $p = .58$, difference = .08, see Figure 1, solid lines). There was some improvement in accuracy across the IR and DR tests, although there was no significant test, $F(1,33) = 2.01$, $p = .17$, $1\text{-}\beta = .28$, or Group x Test effects, $F(2,33) = 2.05$, $p = .15$, $1\text{-}\beta = .39$. We were surprised that the control participants had improved over the 20 minute interval, despite not practicing. No-one in this group reported practicing during the practice interval, so it is possible that the one-trial pre-test versus retention results might have been somewhat subject to regression to the mean (i.e., the failure on the first trial was not necessarily representative of initial performance level for individuals in this group). Moreover, a closer inspection of the actual juggle revealed differences between the groups.

Comparison of the form scores (max score = 6) for the pre-test relative to the means for the IR and DR tests for the 3 groups yielded significant group effects (as illustrated in Figure 1, dashed lines). Based on preplanned contrasts, the Control group was rated more poorly overall, than the two practice groups (*p*

=.024, difference = .60), but the two practice groups did not differ from each other (*p* =.15, difference = .42). Importantly there was a Group x Time interaction, F(3.13,50.04) = 2.89, $p<.05$, $\eta_p^2 = .15$ as shown in Figure 1 (dashed lines). In the IR and DR tests, only the two practice groups showed significantly improved performance relative to their pre-test values. In terms of group differences, there were no differences during the pre-test, and in both retention tests only the Observe + PP group was significantly more accurate than the Control group. Analysis of the retention trials was characterized by a significant linear improvement across trials, F(1,31) = 4.73, $p<.05$, $\eta_p^2 = .13$, but Trials did not interact with Group (F=1.12, *1-ß* = .50).

2. Observers think they learn from watching

Confidence increased across practice blocks as evidenced by a significant block effect, F(1.23, 28.06) = 32.10, $p<.01$, $\eta_p^2 = .59$ (see Figure 2). There were significant linear and quadratic trend components to this effect (*p*s <.01). There was no Group x Block interaction (F<1), but the Observers were more confident throughout practice than the Observe + PP group, F(1,22) = 4.81, $p<.05$, $\eta_p^2 = .18$.

This general increase in confidence across blocks that was observed at the group level was also observed at the individual level. For the Observe-only group, all participants believed they could juggle with 2 balls by the end of the observation period. Five people changed their perceptions of ability from “no” (not able) to “yes” (able), with the majority reporting a perceived ability to juggle after seeing only one juggling demonstration (although their confidence was variable). We have plotted confidence as a function of trial number for individuals in the Observe-only group in Figure 3. Four of the observers did not show a change in confidence (of 10% or more, remaining at 50, 70, 80 and 90-100% confident throughout the observation period; see dashed lines Figure 3). The remaining 8 participants were characterized primarily by a gradual increase in confidence in early trials (t1-t10, n=2), until the middle of practice (t1-t25, n =3) or throughout practice (n=3). This suggests that the majority of observers believed they were learning or gaining advantages from watching and that perceptions of improvement mostly occurred early in practice.

For the Observe + PP group, 2 participants showed no change in their perceptions of ability from “not able” to “able” throughout the 50 practice trials. The remainder believed they could perform the task, two believed they could perform from trial 1 onwards, whereas 8/12 changed their perceptions of ability from “not able” to “able” with successive practice and observational experience. This happened after the first trial for 3 participants, but within the first 10 trials for the remainder. All participants showed a change in confidence across practice trials of >10 %. These increases ranged from relatively small (i.e., n= 4 ≤ 30%; 3-15, 55-80, 75-100, 50-70%) to relatively large (i.e., n = 8 ≥ 40%; 30-70, 0-50, 10-70, 30-95, 5-80, 10-85, 5-95, 5-100%).

With respect to sudden jumps in ability perceptions (i.e., a change in perception of ability coupled with an increase in confidence of 20 % or more across successive trials), this was seen in 3/12 of the Observe-only group and 5/12 of the Observe+PP group. For both groups, these jumps in confidence and perceptions of ability were often accompanied by prompted verbalizations about the trajectory of the balls (cross-over/M-shaped trajectory) and the need for asymmetry in release of the balls. In general, verbalizations across the two groups were similar but the Observe-only group made less comments overall and unlike participants who also physically practiced, their comments were more related to what the balls should do (e.g., throwing the balls more slowly, or throwing the balls up, rather than out), rather than what the juggler should do.

3. Perceptions of ability show some congruence to actual ability

There was evidence that confidence and performance were correlated for the Observe + PP group. Participants who were more confident in practice overall were also more accurate (in terms of proportion of successes), $r(10) = .70$, $p<.01$. However, confidence and ability from trial to trial were not as well correlated. The within subject Spearman correlations ranged from $r = 0 - 0.44$ ($M_r = .15$; $SD_r = .17$). Confidence ratings for successful versus failed trials were statistically different (success $M = 64.69\%$; fail $M = 59.23\%$; $t_{obs} = 2.30$, $p = .042$, $d = .22$) but the effect size was small (~5% change in confidence) suggesting that perceptions of ability showed only some congruence with actual ability.

With respect to confidence ratings and outcome success in IR for the Observers, confidence in their last 5 trials of practice correlated with their performance on the retention test ($r = .55$, $p<.05$). Their accuracy perceptions were as well matched as participants who actually got to perceive success during practice through observing then physically attempting the skill (Observe + PP, $r = .48$, $p<.05$).

Summary and Discussion

In this first experiment we showed that learning occurs from watching a person repeatedly practice a novel motor skill (i.e., 2 ball juggle). Although group differences were not seen for mean number of successful throws during retention, the two practice groups were more accurate than Control participants with respect to their general juggling performance, improving significantly from pre-test in the way they juggled.

Importantly, perceptions of ability and confidence in this ability increased during observational trials for the majority of participants and all the observers believed they could perform the 2-ball juggling skill by the end of the observation period. Confidence increased for the majority of participants and in general this increase was incremental in nature. Only 3 people showed what might be considered learning insights (i.e., relatively large jumps in perceptions of ability) as a result of observation-only (5/12 in the Observe + PP group), that were tied to explicit knowledge statements relating to the ball trajectory pattern and the need to throw the balls at different times (i.e., the "throw-throw" part of the verbal strategy that is tied to success at this task).

In terms of the match between perceptions of ability and actual ability, there was evidence that confidence and performance were related, although not as strongly as might be expected for participants who actually experienced success or failure in practice. That is, the Observe + PP group showed only a ~5% increase in confidence for trials that were successful in practice, versus not successful and their confidence was not more related to subsequent success in immediate retention than participants in the Observe-only group. However, the Observe-only group was more confident overall, suggesting that actual physical practice did have a moderating influence on perceptions of ability. Theoretically, there is reason to think that action observation and actual execution should be well matched, in view of ideas that there is a common code underpinning both seen and executed actions (Hommel et al. 2001; Prinz 1997) as well as a neurophysiological basis for these claims (e.g., Rizzolatti and Craighero 2004).

Due to some outstanding questions in this first experiment related to the match between confidence and ability as a result of observational practice, we conducted a second study designed to more directly probe this relationship by allowing a practice attempt directly following perceptions of success. We compared 2 groups who differed in their perceptions of ability to perform the juggling task after watching a successful model. We limited the number of practice attempts following high or low ratings of perceived success in order to allow stronger conclusions about the role of observation on motor learning and perceptions of skill. Based on results from Experiment 1, we predicted that perceptions of ability would be matched to actual performance, such that participants who state high-perceived ability would be more successful than those that do not. As with Experiment 1, we also measured change in perceptions of ability/learning following physical practice attempts. We predicted that ability ratings would be adjusted to match actual success, that is, ability perceptions and confidence ratings would go down following unsuccessful attempts and increase for successful attempts.

Experiment 2

Methods

Participants and Groups

Twenty university students (*M* age = 21.0 yr, *SD* = 2.8, range = 18-30 yr) were newly recruited to participate in this experiment and were pseudo-randomly assigned to two observer groups; High-perceived ability (F = 6, M = 4) and a yoked/matched Low-perceived ability group (F = 8, M = 2). None of the participants reported having previous experience with juggling. Three additional participants were excluded from analysis (and thus did not have a Low-perceived ability pair) due to the fact that they were scheduled to be in the High-perceived ability group yet at no point did their confidence ratings reach our criterion of 80% (thus preventing any physical practice attempts).

Task and Apparatus

Same as Experiment 1.

Procedure

The procedures were similar to those of Experiment 1 with two major exceptions. The experiment was conducted on one day only, involving only an observational practice phase (50 observation trials) and a subsequent immediate retention test (5 trials). As with Experiment 1, during practice all participants were asked whether or not they believed they could juggle with 2 balls on the next trial and to give a confidence rating in their perceived ability from 0-100%. Different to the first experiment, once the participant in the High-perceived ability group answered that they could successfully juggle the 2 balls with a confidence rating of 80% or higher they were given one physical practice attempt. Participants in the high perceived ability group were given up to 5 physical practice attempts throughout the duration of practice following trials where ability perceptions remained high (with the constraint that a physical practice attempt was only given a maximum of once every 5 trials). These participants were matched for physical practice (amount and time) to participants who did not show the same high perceptions of ability on the corresponding first trial. This allowed for a comparison of High- and Low- perceived ability groups on their first physical practice attempt.

Data Analysis

Behavioural analysis

Mean proportion success was again calculated for acquisition as well as for immediate retention (IR). These data were analyzed in two separate independent t-tests. We again performed secondary analyses on video data to score the juggle based on 3 criteria related to the success of the throws and catches. One person from each of the groups did not have video data in retention (in both cases the cameras had not been turned on) and one participant from the Low-perceived ability group was missing data from one trial in practice. The remaining data were analyzed in two separate ANOVAs (for practice and IR), with Group as the between variable and Trial (5) as the RM factor. Again, an inter-rater reliability analysis was performed on these data, whereby a second rater scored 2 randomly chosen participants in each group (n = 4). The intra-class correlation coefficient, based on the single measure, was again high (R = .94) such that all other ratings were completed by one rater only.

Confidence

The confidence ratings of the two observer groups were compared across 5 blocks of acquisition (10 trials/ block) in a 2 Group x 5 Block RM ANOVA. To evaluate how observation and physical practice differentially affected confidence for the 5 practice attempts we also calculated a change in confidence score. This was based on confidence before and after each physical practice attempt (i.e., change in confidence after PP = $PP_{t+1} - PP_t$, where PP = Physical Practice and t = trial) compared to a change in confidence before and after the next observe-only trial following the PP attempt (i.e., change in confidence after observation = $PP_{t+2} - PP_{t+1}$). As with Experiment 1, we also looked at change in confidence on an individual level to see whether confidence increased gradually or more suddenly.

Significant effects involving more than 2 means based on repeated measures factors were followed up with Tukey HSD analysis ($p<.05$). Violations to sphericity were noted and where significant, Greenhouse-Geisser corrections to df were applied.

Results

1. *Perceptions matched performance for Low-perceived ability participants*

All participants in the Low-perceived ability group failed to reproduce the 2-ball juggling skill on their first physical practice attempt, showing accuracy in their assessment of their (low) motor competence of the observed task. However, only 3/10 High-perceived ability participants successfully performed the skill, indicative of overconfidence in perceived ability. There was however, a significant correlation between confidence rating on attempt 1 and success on the trial (Spearman's rho = .53, p =.02). A similar significant correlation was seen for the second attempt, but not thereafter.

Across the 5 trials of physical practice, although the High-perceived ability group was generally more accurate than the Low-perceived ability group (proportion correct = .44 vs .22 respectively) they were not significantly different in practice, t_{obs} (18) = 1.53, p = .14, d =.72 or in IR, t(18) = 1.56, p =.14, d = .74.

As with Experiment 1, we also used a more subtle measure of performance based on post-trial analyses of the videos. The High-perceived ability group scored more highly in practice (M = 4.70, SD = .72) than the Low-perceived ability group (M = 3.73, SD = .76), F(1,17) = 15.15, p =.001, η_p^2 = .47 and both groups improved across physical practice attempts, F(4,68) = 4.10, p<.01, η_p^2 = .19 (there was no Group x Trial interaction, F=1.24). Although the group differences remained in retention, F(1,16) = 5.20, p<.05, η_p^2 = .25, there were no trial related effects (both Fs<1). These data show that perceptions of ability are related to actual ability and that despite similar practice experiences (watching and attempting), initial differences in perceived ability continue to translate to better approximations of the juggle action (if not overall success).

2. *Perceptions of ability and confidence increase with repeated observations*

In Figure 4 we have plotted mean confidence ratings for the two groups as a function of trial to illustrate the gradual improvement for both groups (at least at a mean level) as well as the increased confidence ratings for the High-perceived ability group. This was confirmed statistically by a group effect, F(1,18) = 10.06, p<.01, η_p^2 = .36. The High-ability group was more confident (M = 88.49%, SD = 7.11) than the Low perceived ability group (M = 59.66%, SD = 27.92) and a block effect, that was described by linear and quadratic trend components (ps<.01). In both groups, confidence increased until trial 20 and thereafter showed a plateauing, at least at the group level. There was no Group x Block interaction (F<1). As with Experiment 1, these data show that observational practice leads to an increase in confidence in ability to perform the seen action. Although physical practice was interspersed with observation, given the low amount of practice trials and the results from Experiment 1, we suspect that observation played a significant role in changing perceptions of ability.

Indeed, a positive change in confidence was only seen following observation-only trials, versus physical practice (PP) trials, at least for the Low-perceived ability group. That is, although the main effect of trial type (i.e., PP or Observe) did not yield a significant difference in confidence between the two types of trials, $F(1,18) = 4.08$, $p = .059$, $\eta_p^2 = .19$, $1\text{-}ß = .48$, there was a significant Group x Trial type interaction, $F(1,18) = 5.62$, $p < .05$, $\eta_p^2 = .24$. For the High-perceived ability group, confidence did not change significantly when comparing trials following physical practice (M = -1%, SD = 12.5%) to trials following observation (M = -2%, SD = 10.6%). So for participants who had generally higher perceptions of ability quite early in practice, regardless of performance or what they were seeing, on average, confidence in their ability did not change. However, for the Low-perceived ability group, there was a significant difference between the two types of trials with a decrease in confidence following a physical practice attempt (M = -7.2%, SD = 17.5), yet an increase in confidence following the next observation trial (M = +5.3%, SD = 8.6). This suggests that observational practice plays a role in restoring confidence in perceived ability despite potential physical set-backs.

At the end of the practice phase, all participants in the High-perceived ability group believed in their ability to successfully perform the 2 ball juggle task in comparison to 70% of participants in the Low-perceived ability group. Five participants in the High-perceived ability group believed in their ability to perform the juggle task from the first demonstration trial onwards and their perceptions did not change (irrespective of their relative degrees of success). Three participants in this group changed their response to “yes” (able) within the first 10 trials and the remainder within the first 20 trials. For the Low-perceived ability group, 1 person believed they could perform the juggling task from trial 1 (with low confidence, as a requirement for our group assignment), 4 changed their perceptions of ability from “no” to “yes” within 10 trials, 2 people never changed their perceptions (from no to yes), 2 took between 30-40 trials and 1 person changed their ability perceptions from “no” to “yes” within the first 10-20 trials and then back again to “no” on the last 20.

Confidence gradually increased for just over half of the participants (n = 7) in the High-perceived ability group (within the first 5-20 trials, plateauing thereafter). Two of the participants remained confident throughout practice and one participant showed considerable variability in their confidence. For the Low-perceived ability group, one person did not change in their confidence (0% throughout), two participants were highly variable and the remainder showed an increase in confidence within the first 5-20 trials, plateauing thereafter.

General Discussion

We studied the role that observation plays in informing learners' perceived motor competence (and actual learning) in the performance of a two-ball exchange juggling task. In the first Experiment, we expected observers (either pure observational practice or interspersed physical and observational practice) to have a learning advantage over control participants not receiving practice. Although the 3 groups did not differ significantly in their overall success on the task, the two practice groups improved in their approximation of the juggle action and more participants in the two practice groups could successfully perform the juggle task after practice in comparison to controls. Perhaps somewhat surprisingly, even after 50 trials of physical practice, the physical practice group did not perform with more accuracy in retention than the observation only group (*cf.* Scully & Newell, 1985; Shea et al. 2000).

Importantly, even without any physical practice, confidence gradually increased across practice for the majority of participants in the Observe-only group. This supports the suggestion that observational practice enhances perceptions of ability/learning even in the absence of performance-based feedback. Interestingly, and somewhat surprisingly, the Observe-only group was more confident throughout practice than the Observe + PP group. A somewhat similar finding was shown in Experiment 2, when we compared change in confidence following physical practice attempts to observe-only trials. Confidence only increased following observation trials and not physical practice attempts (although this finding was limited to the Low-perceived ability participants; the High-perceived ability participants showed no change in confidence following either type of trial or feedback).

In Experiment 2, conceptions of ability were well matched to actual ability for the Low-perceived ability group, but the High-perceived ability group was overconfident in their ability. The two groups did not differ statistically in their overall juggling success during or after practice, although the High-perceived ability group showed a better approximation of the juggling action. We had suspected that ability perceptions would be well matched to ability in view of common codes that allow a mapping of observed actions onto action representations in the observer. Although there was some congruence in these mappings (in Experiment 1 and 2), these were not as strong as we had thought, suggesting that awareness of ability does not necessarily develop in tandem with actual ability and that feelings of knowing that we cannot do something are more accurate than feelings of knowing that we can.

A general lack of change in ability conceptions following unsuccessful juggling attempts, at least for the High-perceived ability group in Experiment 2 is consistent with social psychology research, whereby evidence of overconfidence in poor performers on social and intellectual tasks is attributed to the lack of skills needed to accurately recognize their deficits (Ehrlinger et al. 2008). An inability to recognize one's own motor ability may lead to overly optimistic views of one's capability, potentially leading to a vicious circle of low competence in actual performance.

In early models of observational learning, based primarily on social learning theory (Bandura 1977), one of the benefits of observational practice was assumed to be related to a change in efficacy perceptions. Despite these initial ideas, there has been a lack of research in this field directed to exploring how repeated observations impact perceptions of efficacy. In these two experiments we have shown that pure observational practice and observational practice with limited practice attempts positively impacts confidence judgments in ability to produce the observed task, sometimes despite physical evidence to the contrary. Because of the relative importance that has been attached to the role of positive affect and competence perceptions for learning (see Wulf and Lewthwaite 2012), this potential positive role of observational practice that has thus far been ignored or underestimated in the motor learning literature, should be given renewed attention.

With respect to how perceptions of ability developed, there was more evidence that for observational practice this was gradual, rather than more all-or-none, indicative of the one-trial learning phenomenon. It has been suggested by Randall (1999) that complex timing patterns are less likely to be acquired in an all-or-none fashion, but rather more spatial subcomponents of movement tasks lend themselves better to one-trial acquisition. Despite our thoughts that this task might lend itself well to a more all-or-none acquisition, this was not the case and instead learning, or perceptions of learning, appeared to be more gradual.

In summary, across 2 experiments we showed benefits from observational practice associated with learning the 2-ball juggling action. Importantly, observational practice enhanced perceptions of ability despite a lack of performance-based feedback, or despite performance-based feedback to the contrary. Observation trials generally resulted in higher conceptions of ability (i.e., confidence) relative to physical practice only trials and potentially functioned to restore confidence in ability. Confidence generally increased gradually across repeated observations (especially early in practice) and showed a degree of congruence to actual ability, although in Experiment 2 it was the low-perceived ability participants who were more accurate in their ability perceptions, compared to the high-perceived ability group who showed overconfidence in their eventual success. Given the recent importance that has been attached to competency perceptions for motor learning (e.g., Lewthwaite and Wulf 2012) and evidence that action observation depends on the initial skills of the observer (e.g., Calvo-Merino et al. 2006), these findings serve to give more insight into how action observation functions in the early stages of motor skill learning.

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Ethical standards

All participants gave written informed consent prior to inclusion in the studies and the studies were conducted in accordance with the ethical guidelines of the University and hence with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

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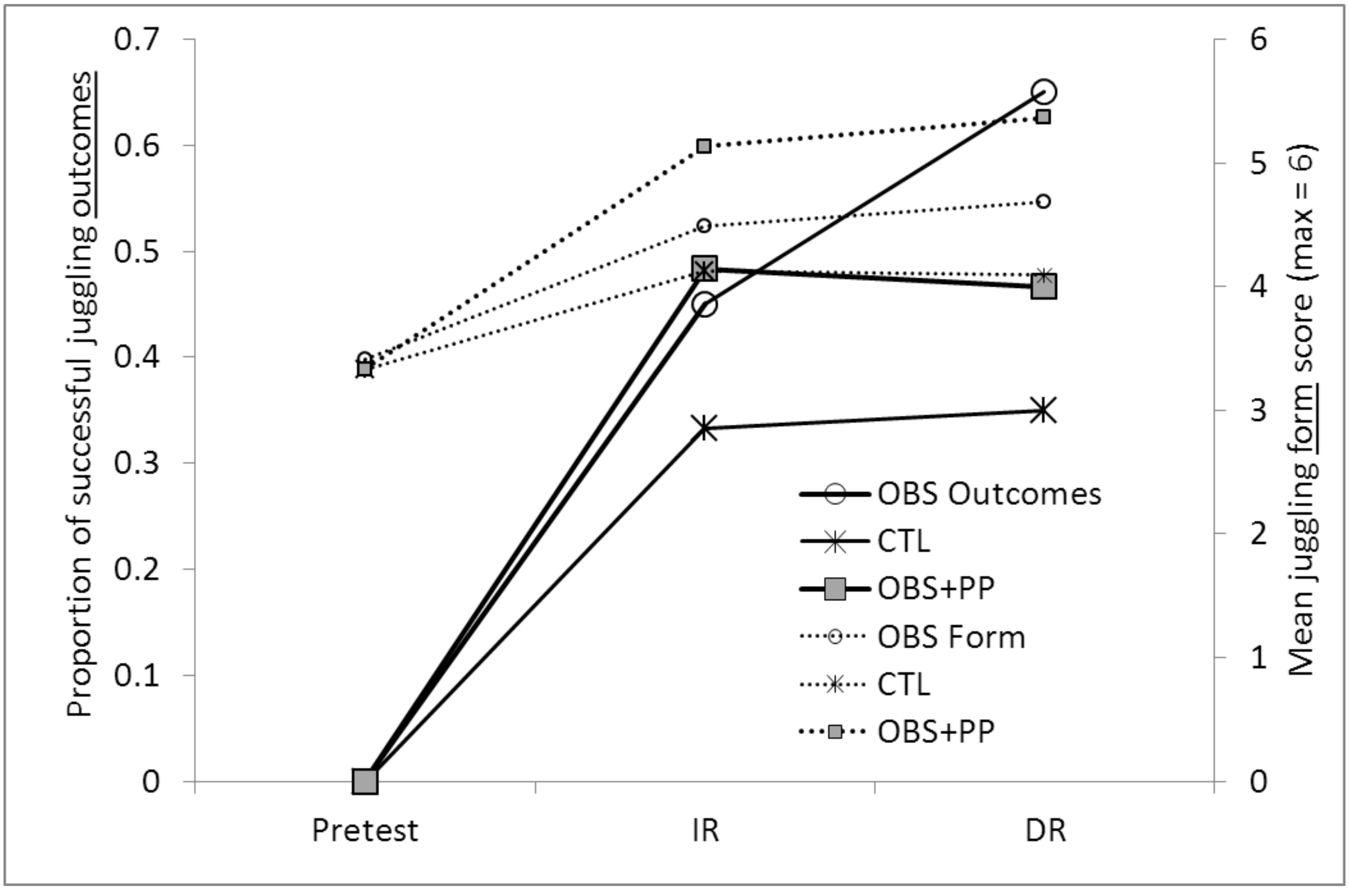
Figure captions:

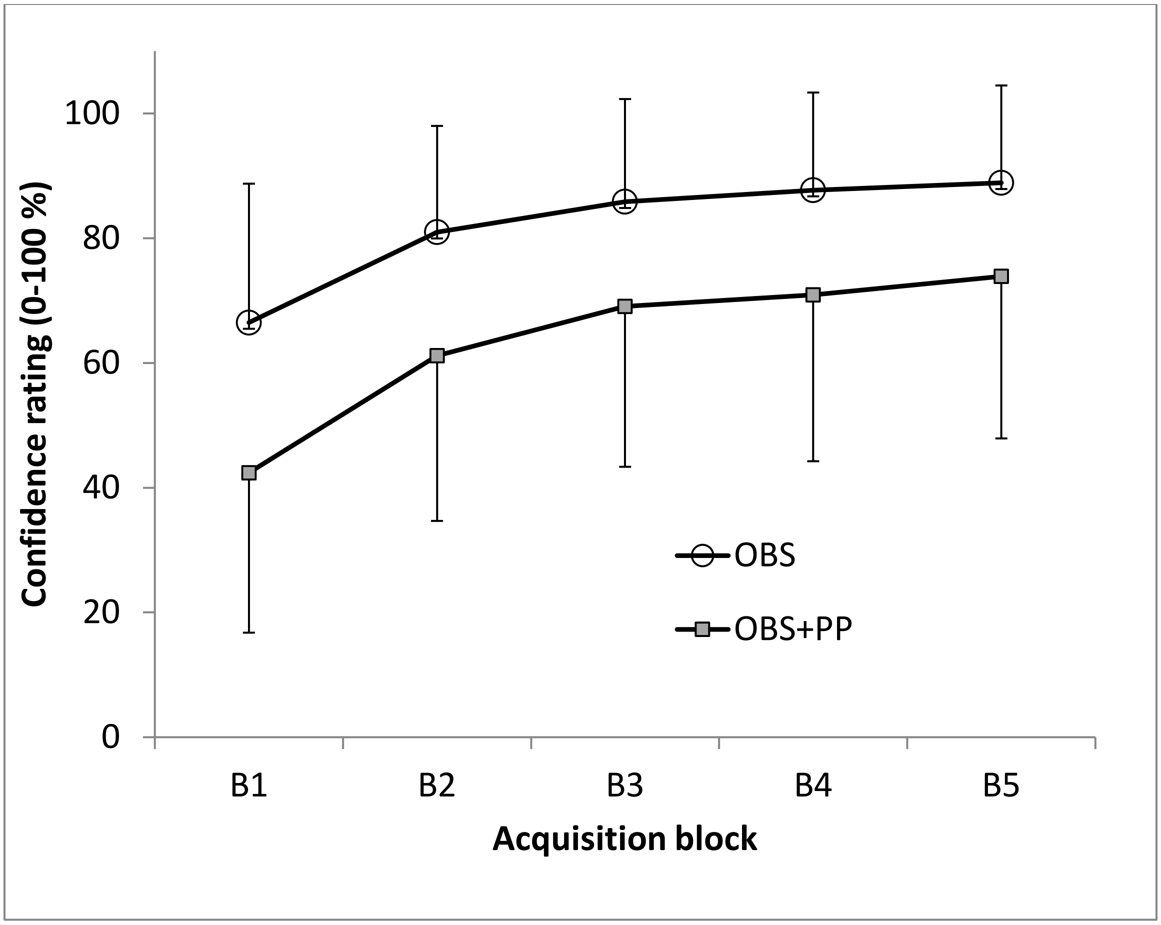
Fig. 1 Exp. 1: Proportion of successful juggling outcomes (solid lines) and mean juggling form scores (dashed lines) for each phase of the experiment (Pre-test, 1 trial, Immediate retention (IR), and Delayed retention (DR), means of 5 trials) as a function of group (OBS = observers, CTL = no practice, controls and OBS+PP = observation and physical practice).

Fig 2. Exp. 1: Confidence ratings as a function of group (OBS = observers, OBS+PP = observers + physical practice) and acquisition block (5 trials/block).

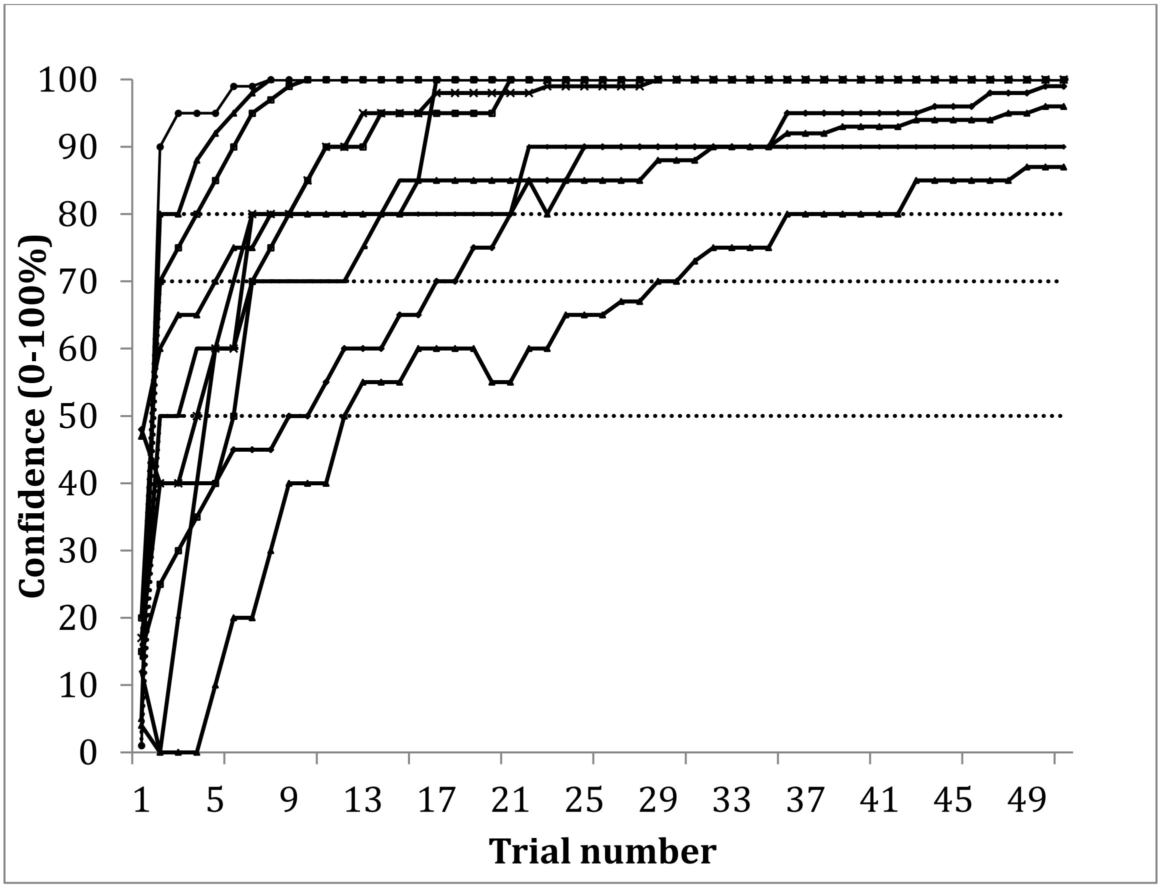
Fig 3. Exp. 1: Individual confidence ratings for participants in the Observation-only group across the 50 trials of observational practice only.

Fig 4. Exp. 2: Confidence ratings as a function of group and trial during acquisition for the High and Low-perceived ability groups.

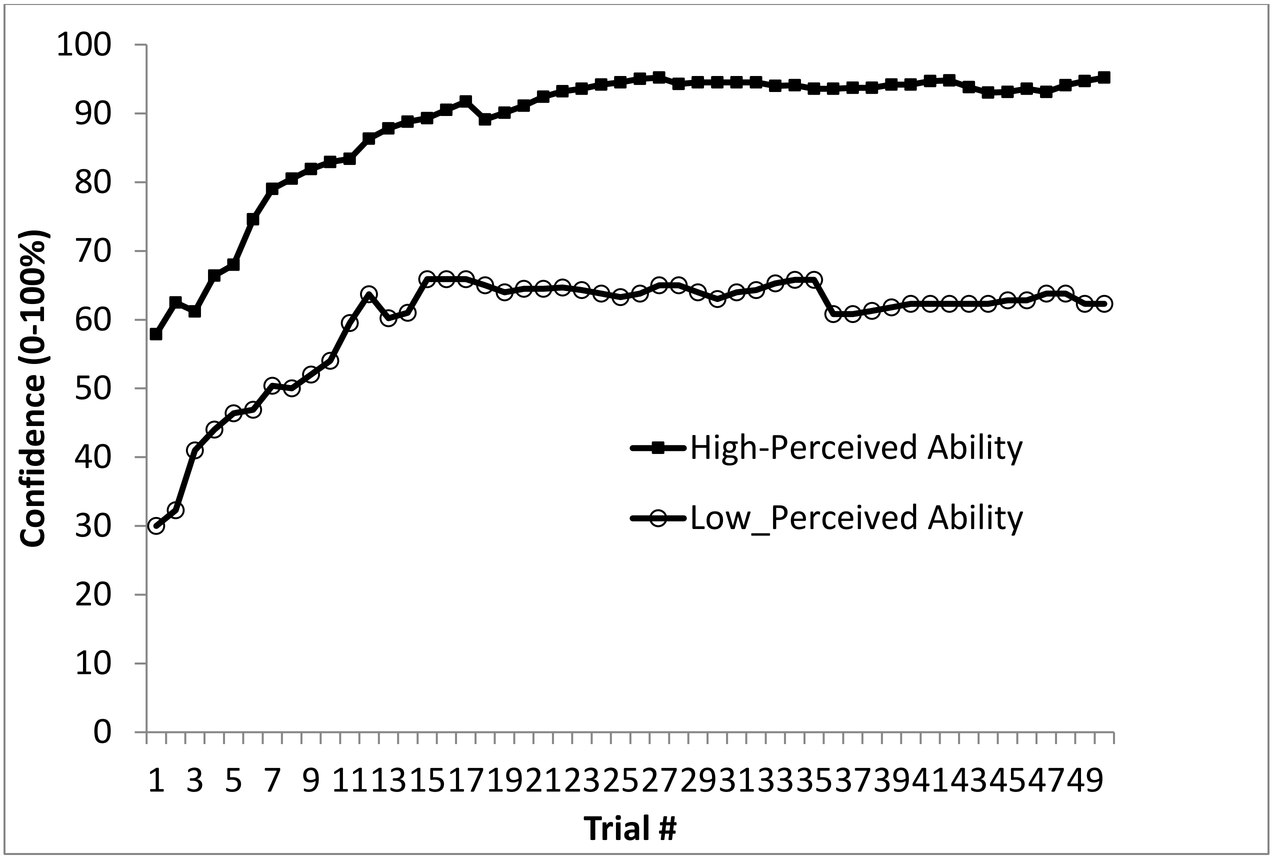

0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Proportion of successful juggling outcomes
6
5
4
3
2
1
0
Mean juggling form score (max = 6)
Pretest
IR
DR
OBS Outcomes
CTL
OBS+PP
OBS Form
CTL
OBS+PP



100
80
60
40
20
0
Confidence rating (0-100 %)
OBS
OBS+PP
B1
B2
B3
B4
B5
Acquisition block



Confidence (0-100%)
100
90
80
70
60
50
40
30
20
10
0
1
5
9
13
17
21
25
29
33
37
41
45
49
Trial number


100
90
80
70
60
50
40
30
20
10
0
Confidence (0-100%)
High-Perceived Ability
Low_Perceived Ability
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49
Trial #