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Impacts of autonomy-supportive versus controlling instructional language on motor learning

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ABSTRACT

The authors examined the influence of autonomy-supportive (ASL), controlling (CL), and neutral instructional language (NL) on motor skill learning (cricket bowling action). Prior to and several times during the practice phase, participants watched the same video demonstration of the bowling action but with different voice-over instructions. The instructions were designed to provide the same technical information but to vary in terms of the degree of choice performers would perceive when executing the task. In addition to measurements of throwing accuracy (i.e., deviation from the target), perceived choice, self-efficacy, and positive and negative affect were assessed at the end of the practice phase and after a retention test without demonstrations and instructions on Day 2. ASL resulted in perceptions of greater choice, higher self-efficacy, and more positive affect during practice than CL, and enhanced learning as demonstrated by retention test performance. Thus, granting learners autonomy appeared to endow them with confidence in their ability, diminished needs for control of negative emotional responses, and created more positive affect, which may help consolidate motor memories.

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1. Introduction

Over the past few years, converging evidence from various lines of research has highlighted the motivational nature of the influence that different variables have on motor skill learning. Practice conditions that support fundamental psychological needs such as competence, autonomy, and social relatedness (e.g., Deci & Ryan, 2000, 2008) appear to create circumstances that optimize performance and learning (see Lewthwaite & Wulf, 2010a, 2012; Sheldon & Filak, 2008). For instance, the value of satisfying learners' need to feel competent is highlighted by findings showing enhanced learning with feedback after successful trials (e.g., Chiviacowsky & Wulf, 2007), positive social-comparative feedback (e.g., Lewthwaite & Wulf, 2010b), or video feedback about learners' best performances (e.g., Clark & Ste-Marie, 2007). Social relatedness concerns the need for social inclusion and is made possible or threatened in a variety of team, group, or dyadic practice situations (e.g., Shea, Wulf, & Whitacre, 1999; Shebilske, Regian, Arthur, & Jordan, 1992; see Lewthwaite & Wulf, 2012). Motor learning researchers are also increasingly realizing that these benefits of self-controlled, or learner-controlled, practice may be motivational in nature as well, in that they may satisfy the basic psychological need for autonomy (see Lewthwaite & Wulf, 2012; Sanli, Patterson, Bray, & Lee, 2013).

The aim of the present study was to further explore the role of autonomy support in motor learning. Autonomy is related to people's basic need to control or actively participate in determining their own actions and behavior. Allowing individuals to exercise control over the environment may not only satisfy a basic psychological need but may be a biological necessity (Leotti, Iyvengar, & Ochsner, 2010; Leotti & Delgado, 2011). Studies with both animals (Catania & Sagvolden, 1980; Voss & Homzie, 1970) and humans (Tiger, Hanley, & Hernandez, 2006) suggest that exercising control is inherently rewarding (Leotti & Delgado, 2011). The often seen learning advantages of autonomy-supportive (i.e., self-controlled or learner-controlled) practice conditions relative to more controlling (i.e., yoked) conditions (for reviews, see Sanli et al., 2013; Wulf, 2007), are presumably due in part to the positive motivational consequences of perceived control.

In the present study, we extended the inquiry into the role of autonomy support by examining whether the way in which task instructions are worded may have an influence on learning. Would instructions that suggest to learners a certain degree of choice in how they perform a task lead to more effective learning than more prescriptive instructions that imply no room for choice, or even "neutral" instructions? In a study by Reeve and Tseng (2011), instructions related to a puzzle task were worded in an autonomy-supportive, controlling, or neutral way. Participants in the autonomy-supportive group reported higher perceived competence than did participants in either the neutral or controlling-language group, perhaps because autonomy-supportive instructions conveyed a general sense of confidence or trust in learners which in turn might have contributed to task-specific self-efficacy. Unfortunately, the authors did not report performance on the puzzle task as a function of instructional language.

Autonomy-supportive versus controlling language may also have affective consequences that, in turn, may have differential effects on learning. Given that exercising control seems to be inherently rewarding (e.g., Leotti & Delgado, 2011; Voss & Homzie, 1970), autonomy-supportive language might induce greater positive affect. Consistent with this view, in Reeve and Tseng's (2010) study, participants in the autonomy-supportive group (and neutral language group) reported significantly greater emotional engagement (i.e., enjoyment, fun, curiosity, interest) than did participants in the controlling-language group. In contrast, controlling language induced stress, as indicated by increased cortisol levels. It is possible that self-regulatory attempts at controlling negative emotional responses might take attentional capacity away from the task, thereby degrading learning.

Participants in the present study were asked to learn the cricket bowling action. Similar to Reeve and Tseng (2010), we varied the way in which instructions were presented. For one group of participants (autonomy-supportive language), the instructions were designed to convey a sense of choice, while for another group (controlling language), they offered little option for how to execute the skill. A control group with neutral-language instructions was also included. In addition to any immediate effects the different instructions may have on motor performance, we also wanted to measure more permanent effects on learning. Therefore, a delayed retention test without instructions or reminders was included. Furthermore, we assessed influences of instructional language on participants' perceived choice (manipulation check), as well as self-efficacy, and positive and negative affect.

2. Method

2.1. Participants

Forty-eight undergraduate students (21 females, 37 males) with a mean age of 22.3 years (SD: 2.4) participated in this experiment. Informed consent was obtained from all participants. Participants had no prior experience with the experimental task, and they were not aware of the purpose of the study. The study was approved by the university's institutional review board.

2.2. Apparatus and task

The task involved learning a modified cricket bowling action. After watching an instructional video demonstrating and describing the skill (see below), participants were asked to perform the bowling action with a tennis ball to a target that was hung in a net (2.1 × 2.1 × 1.4 m; Atec Catch Net; Sparks, Nevada) from a distance of 10 m. The target was a bull's eye. The inner circle had a radius of 15 cm and was surrounded by 3 concentric circles with radii of 30, 45, and 60 cm, respectively. The center of the bull's eye was 1 m above the ground. A video camera (Flip, Model M3160, Irvine, California) recorded all throws, and the recordings were later used to determine the deviation of each throw from the center of the target. The camera was mounted on a tripod, with the camera lens 1.0 m above the ground. The camera lens was 6 m from the target and was focused on the center of the target from a 20-degree angle. The experimental set-up is illustrated in Fig. 1.

2.3. Procedure

Participants were randomly assigned to one of three groups: autonomy-supportive (ASL), controlling-language (CL), and neutral-language (NL) groups. The groups differed in terms of the voice-over instructions provided with the video they watched prior to the practice phase (see Table 1). The bowling action was demonstrated by the experimenter (first author) who also narrated the clip. The 40-s video clip included a demonstration of the skill from different angles (i.e., left and right side, front, rear), as well as footage of the ball set up and the target. The video clip was presented before each block of 10 practice trials. However, because the first 10 trials were used as a pre-test, participants watched the first video presentation without sound. No extrinsic feedback was provided to participants to minimize interactions with the experimenter (and maximize any effects of the instructional language). After the completion of 60 trials (i.e., 10 pre-test and 50 practice trials), participants were asked to fill out a questionnaire. The questionnaire consisted of 3 questions about participants' perception of choice that were adapted from the Intrinsic Motivation Inventory (McAuley, Duncan, & Tammen, 1989) and served as a manipulation check (e.g., "I believe I had a choice over how to throw as I practiced," "I felt as if it was my own choice how to throw on each trial," "I felt that I could decide how to perform the pitch"). Participants gave ratings on a scale from 1 (no choice) to 10 (a lot of choice).

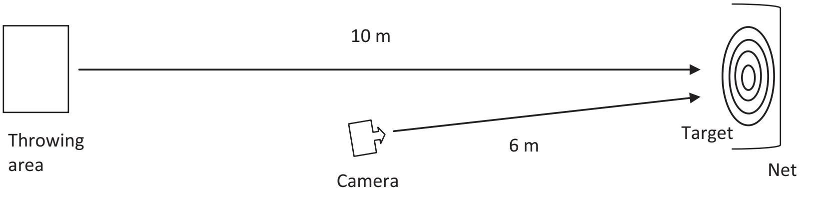

Fig. 1. Experimental set-up. Participants threw from the throwing area at a target (i.e., bull's eye) that was hung in a net. The camera recorded all throws for later scoring.

Table 1
Instructions played over the video clip demonstrating the cricket bowling action (''pitch'') to the ASL, CL, and NL groups.

Autonomy-supportive language	Here is your opportunity to learn a cricket pitch. Please wait to begin your throws until the instruction has ended. The tennis balls are in their holders now but you may organize them in a way that you prefer. Once you begin throwing, feel free to go at a pace you are comfortable with. When starting the approach of the pitch you may want to cradle and deliver the ball in a windmill fashion so the ball travels over the shoulder and not to an angle or to the side. Here is a hint for how to best perform the pitch: Upon releasing the ball focus on the center of the target or the area where you want the ball to bounce before it strikes the target
Controlling language	Your job today will be to learn a cricket pitch and perform it well. You may not begin throwing until you are told so. Make sure all of the tennis balls are in their respective holders. You may only remove one tennis ball at a time. Once you have been told when to commence throwing you must maintain a consistent pace. When initiating the approach of the pitch you must cradle the ball so it travels in a circular pattern. At the apex of the pitch the ball must be directly over the shoulder. Do not throw it at a side angle. When initiating the release you need to focus on the center of the target or the bounce area below the target
Neutral language	Today you will be practicing a cricket pitch. Begin throwing once instruction has ended and the court is set. The tennis balls are in their respective holders. At the start of practice the tennis balls will be kept in their respective holders. Perform each series of throws in an efficient and consistent manner. At the beginning of each pitch cradle and swing the ball so it travels in a circular fashion before it is released. Before the release of the ball, make sure it travels over the shoulder. At the release maintain focus on the center of the target or the bounce area prior to the target

The questionnaire also included a self-efficacy measure which consisted of 3 statements that reflected the participant's confidence of being able to achieve an average score of 5, 3.33, or 1.67 on a scale from 1 (not confident at all) to 10 (extremely confident). The scores referred to the target, with the assumption that 5 points would be awarded for hitting the bull's eye, and 4, 3, 2, 1, or 0 points for hitting the surrounding zones, the area outside the largest zone, or complete misses. (The dependent measure of throwing accuracy used in our data analyses was the deviation from the bull's eye in cm, however.) The Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegan, 1988) was used to measure positive and negative affect. It consists of a list of adjectives that describe positive (e.g., interested, excited, strong) and negative feelings or emotions (e.g., distressed, upset, guilty). Participants were asked to rate each word in terms of how they felt at the present moment on a scale from 1 (very slightly or not at all) to 5 (extremely). One day later, all participants completed a retention test consisting of 20 trials. No video demonstrations or instructions were provided before the retention test. Finally, participants filled out the same questionnaire that they had completed on Day 1.

2.4. Dependent variables and data analysis

To ensure that the instructions [e.g., ''feel free to go at a pace you are comfortable with'' (ASL) versus ''you must maintain a consistent pace'' (CL)] did not differentially affect participants' pacing, or duration of practice, in the different groups, we determined the duration of each of the 5 10-trial practice blocks for each participant from the video recordings. The average completion times (i.e., time from first to last pitch in seconds) were analyzed in a 3 (groups) $\times$ 5 (blocks) analysis of variance (ANOVA). The deviation (in cm) from the bull's eye of each throw was also determined from the video recordings. All data were averaged across blocks of 10 trials. The pre-test data were analyzed in a one-way ANOVA, and the practice data were analyzed in a 3 (groups: ASL, CL, NL) $\times$ 5 (blocks of 10 trials) analysis of variance (ANOVA) with repeated measures on the second factor. Retention data were analyzed in a 3 (groups: ASL, CL, NL) $\times$ 2 (blocks) ANOVA with repeated measures on block. Bonferroni adjustments were made for all post hoc tests. Participants' ratings of perceived choice and self-efficacy were each averaged over the 3 respective statements. Ratings of the positive and negative words on the PANAS were averaged across words to obtain measures of positive and negative affect, respectively. Perceived choice, self-efficacy, and positive and negative affect were each analyzed separately for Days 1 and 2 in one-way ANOVAs and post hoc tests with Bonferroni adjustments.

3. Results

3.1. Pacing

All three groups had similar completion times on all practice blocks, with average times of 75.9 s (ASL), 76.4 s (NL), and 77.1 s (CL). There was no main effect of group, $F\,(2, 45) = .15$, $p = .87$. The main effect of block, $F\,(4, 180) < 1$, and the interaction of group and block, $F\,(4, 180) < 1$, were also not significant.

3.2. Throwing accuracy

Accuracy in throwing performance can be seen in Fig. 2. All groups performed similarly on the pre-test, $F\,(2, 45) < 1$.

All groups reduced their deviations from the target across practice blocks. However, the ASL group tended to have consistently smaller errors than the other groups, particularly the CL group. The main effects of both block, $F\,(4, 180) = 7.09$, $p < .001$, $\eta^2 = .14$, and group, $F\,(2, 45) = 4.09$, $p < .05$, $\eta^2 = .15$, were significant. Post-hoc tests showed that the ASL group outperformed the CL group, $p < .05$. The Group × Block interaction was not significant, $F\,(8, 180) < 1$.

On the retention test, the ASL groups demonstrated the greatest accuracy, whereas the CL group had the largest errors. The Group main effect, $F\,(2, 45) = 3.49$, $p < .05$, $\eta^2 = .13$, was significant. Post-hoc tests indicated that the ASL group differed significantly from the CL group, $p < .05$. The NL group did not differ significantly from either group, *ps* > .05. Even though only the ASL and NL groups showed a numerical reduction in their target deviations from the first to the second block, while the CL group did not, the Block main effect was significant, $F\,(1, 45) = 8.77$, $p < .01$, $\eta^2 = .16$. Also, the Block × Group interaction failed to reached significance, $F\,(2, 45) = 2.51$, $p = .092$.

3.3. Perceived choice

The ASL group experienced greater choice during practice than did the other two groups (see Fig. 3a). The Group effect was significant, $F\,(2, 45) = 6.52$, $p < .01$, $\eta^2 = .23$. Post-hoc tests showed that the ASL group differed from both the CL ($p < .01$) and NL groups ($p < .05$), whereas the CL and NL groups did not differ from each other, $p > .05$.

Although the ASL group tended to have the highest choice ratings at the end of Day 2, the effect of group was no longer significant, $F\,(2, 45) = 2.31$, $p = .11$, presumably because no instructions were given on Day 2.

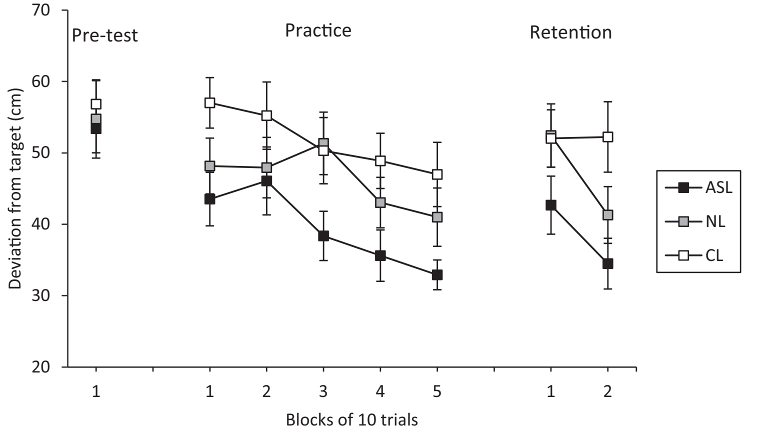

Fig. 2. Target deviations for the ASL, NL, and CL groups on the pre-test, and during practice and retention. Error bars represent standard errors.

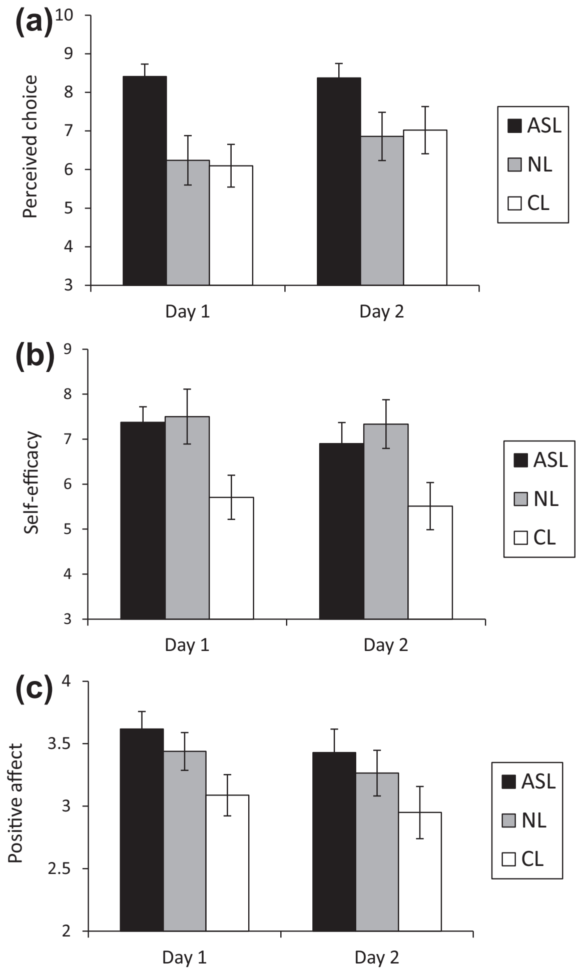

Fig. 3. Perceived choice (a), self-efficacy (b), and positive affect scores (c) for the ASL, NL, and CL groups after the practice phase (Day 1) and after the retention test (Day 2). Error bars represent standard errors.

3.4. Self-efficacy

At the end of Day 1, self-efficacy was higher in the ASL and NL groups than it was in the CL group (see Fig. 3b). The Group effect was significant, $F\,(2, 45) = 4.29$, $p < .05$, $\eta^2 = .16$. Post-hoc tests indicated differences between both the ASL and NL groups, which did not differ from each other, $p > .05$, and the CL group, $ps \leqslant .05$.

On Day 2, the CL group again tended to have lower self-efficacy scores than the other groups. The Group effect was significant, $F\,(2, 45) = 3.35$, $p < .05$, $\eta^2 = .13$. However, only the NL group differed significantly from the CL group, $p < .05$.

3.5. Positive and negative affect

At the end of the practice phase, the ASL group exhibited the greatest positive affect (see Fig. 3c). The CL and NL groups experienced somewhat less positive affect. The main effect of group was significant, $F\,(2, 45) = 3.26$, $p < .05$, $\eta^2 = .13$. The ASL group differed significantly from the CL group, $p < .05$.

Negative affect at the end of Day 1 was low and did not differ among the 3 groups (ASL: 1.49; CL: 1.48; NL: 1.64). The main effect of group, $F(2, 45) < 1$, was not significant.

After the retention test, both positive and negative affect appeared to be somewhat reduced relative to Day 1. Even though the ASL group (3.43) tended to show higher positive affect than the CL (2.95) and NL (3.27) groups, the main effect of group was not significant, $F(2, 45) = 1.63$, $p > .05$. Also, negative affect was similar for all groups (ASL: 1.30; CL: 1.29; NL: 1.40), $F(2, 45) < 1$.

4. Discussion

Learning of a novel motor skill (cricket bowling action) was enhanced when instructions were autonomy-supportive rather than controlling. The ASL group showed significantly greater throwing accuracy on the retention test than the CL group. This finding lends support to the idea that learning is facilitated when practice conditions support learners' need for autonomy, or degraded when their autonomy is undermined (cf. Lewthwaite & Wulf, 2012). Even though there has been considerable evidence in the motor learning literature showing that learning is enhanced by learner-controlled practice conditions relative to yoked control conditions (see Sanli et al., 2013), the learning advantages seen under those conditions have only recently begun to be discussed in terms of their autonomy-supportive or motivational impact. Also, motivational correlates of those practice conditions have rarely been assessed. Conversely, in the social-psychological literature, studies have often been limited to identifying interrelations among different motivational variables, without direct measurement of performance or learning (see Sheldon & Filak, 2008; Vansteenkiste, Simons, Lens, Sheldon, & Deci, 2004, for exceptions with cognitive or conceptual performance). The present findings show not only that task instructions – that is, whether they convey a sense of autonomy or not – have different motivational consequences, but also that they have an impact on motor learning.

Ratings of perceived choice after the practice phase were relatively high for ASL participants (8.4 out of 10) and significantly higher than those of the NL (6.2) and CL (6.1) groups. Apparently "neutral" language was not sufficient to induce a sense of control in learners. Rather, more explicit suggestions or the tone associated with them, such as "you may," "feel free," or "here is a hint," appeared to be necessary to give learners a sense of autonomy. Whether the laboratory environment created a greater need for autonomy support than other situations in which the individual's sense of autonomy might be higher and a more "neutral" language may be sufficient, is an open question. Thwarting participants' needs would certainly be expected to have detrimental effects (Sheldon & Filak, 2008).

Interestingly, self-efficacy after practice was similarly high in the ASL and NL groups, but was significantly lower in the CL group. Reeve and Tseng (2011) also reported higher perceived competence ratings for participants trying to solve a puzzle under autonomy-supportive conditions relative to participants in the controlling-language group (although their neutral-language group did not differ from the controlling-language group). Thus, it is possible that controlling instructional language shakes learners' confidence in being able to perform well. In contrast, autonomy support, and to some degree perhaps even neutral instructions, might convey a generalized sense of trust in the learner's abilities. The increased self-efficacy resulting from the perception that others have confidence in one's capabilities might in turn reduce self-related concerns. Some evidence for this notion comes from findings showing that granting performers control over practice conditions resulted in a reduced focus on body positions (Chiviacowsky, Wulf, Lewthwaite, & Campos, 2012) – which has been shown to disrupt movement automaticity and hamper the effectiveness and efficiency of movements (for a review, see Wulf, 2013).

Controlling environments tend to induce stress. Reeve and Tseng (2010) determined cortisol levels as a function of instructional language. Cortisol is considered a stress hormone, and increased levels are thought to reflect coping processes in response to the stress (Dickerson & Kemeny, 2004). In the Reeve and Tseng study, the controlling instructional style increased salivary cortisol, whereas the autonomy-supportive language decreased it, relative to neutral language. Self-regulatory attempts at controlling negative emotions that result from controlling environments might interfere with learning by taking attentional capacity away from the task. Although we did not measure stress levels in the present study, and negative affect ratings were relatively low and did not differentiate between groups, self-regulatory activity may have been heightened in the controlling-language condition and contributed to the limited performance improvement during practice and less-than-optimal learning results.

Participants in the CL group showed clearly less positive affect compared with the ASL group. A similar finding was reported by Reeve and Tseng (2010). Participants in their controlling-language group showed significantly less emotional engagement than did participants in the autonomy-supportive group. Thus, autonomy-supportive and controlling conditions seem to differ in terms of performers' affective reactions. Being in a position to exercise control has been argued to be a biological necessity (Leotti, Iyvengar, & Ochsner, 2010) and seems to be inherently rewarding (Catania & Sagvolden, 1980; Leotti & Delgado, 2011; Voss & Homzie, 1970). Increased motivation to learn under self-controlled practice conditions (Chiviacowsky et al., 2012), for example, may be an indicator of the rewarding function of choice. Choice is also associated with increased activity of brain regions directly involved in reward processing (Leotti & Delgado, 2011). Reward, or positive affect, is associated with phasic increases in dopamine discharge that strengthens neural connections (Ashby, Turner, & Horvitz, 2010). For instance, in a study by Abe et al. (2011), monetary rewards for good performance resulted in more effective learning of a motor task than did punishment (i.e., deduction of money) for poor performance or a control condition. As Abe et al. point out, reward is associated with dopamine-dependent long-term potentiation, which may be a mechanism underlying motor learning. Thus, accumulating evidence suggests that positive affect plays a role in cementing (motor) memories (see also Trempe & Proteau, 2012).

5. Conclusions

The present findings suggest that autonomy-supportive conditions have multiple benefits for learning. Granting individuals autonomy appears to endow them with confidence in their ability to do well (i.e., self-efficacy), thereby reducing self-related concerns and conscious attempts at controlling their movements that hamper automaticity. In addition, attention can be directed to the task at hand, without attentional capacity being diminished by the need to control negative emotional responses to denial of autonomy. Furthermore, the rewarding function of choice seems to result in positive affect, which may not only promote future engagement with the task, but likely has a more direct effect on learning by consolidating motor memories.

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