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Experiments with people are traditionally run with the assumption that, save for a small minority of 'bad' participants, our sample uniformly do and don't do whatever is asked of them. However, movement errors of the kind that were explicitly forbidden by experimenters do occur (Wegner, Ansfield, & Pilloff, 1998; Dugdale & Eklund, 2003; Bakker et al., 2006), indicating a potential for misleading interpretations of findings. Athletes, too, anecdotally report that despite their best efforts the most unwanted movements can be the ones they have most difficulty in preventing, curiously, precisely because they were trying to prevent them. Wegner's (1994) theory of ironic processes of mental control has become the popular explanation for why these ironic errors manifest, yet little experimental consideration has been paid to the prevalence and relative importance of another type of instruction-induced error: over-compensations (de la Peña et al., 2008). Moreover, no investigation has as yet described the consistency with which individuals make ironic or over-compensatory errors across trials, conditions and tasks. Proneness to ironic error is also thought to increase with state and trait anxiety, but again, this has not been systematically tested within a movement context. These gaps in research were the current focus of investigation.

Wegner (1994) explains all mental control as the product of an interaction between two cognitive processes which function as a feedback unit. The first is an effortful, consciously initiated and therefore cognitively demanding intentional operating process which searches for mental content congruent with the desired mental state (e.g. relaxation, happiness, concentration). The second is an unconscious, less demanding-of-effort ironic monitoring process which seeks out and sensitises our attention to mental content which signal the precisely unwanted mental state (e.g. stress, sadness, distraction). When sufficient cognitive resources are retained, the intentional operator overpowers the ironic monitor to create the desired mental state. However, under circumstances where cognitive resources are critically depleted (e.g. by a concurrent mental task, speed demands, stress), the ability of the operator to focus our attention solely toward wanted thoughts becomes limited, leaving the conscious mind hyper-sensitive to unwanted thoughts supplied by the monitor. Essentially, it is now this hyper-sensitivity to unwanted thoughts which causes subsequent attempts at mental and motor control under diminished cognitive capacity to not only fail but, ironically, to backfire and invoke the very thoughts and behaviours we had hoped to avoid.

Ironic effects of mental control have been well documented in various domains (see Wegner, 1994 for a review) beginning with the discovery that instruction to not think of a white bear can leave participants thinking of little else (Wegner et al., 1987). In movement contexts, Wegner, Ansfield and Pilloff (1998) found that when participants were instructed to avoid putting a golf ball past a target spot whilst holding a six-digit number in mind, the frequency of over-shots significantly increased in comparison to participants whom were instructed to avoid over-shooting but not given this memory load. Similar ironic effects were observed in a second experiment in which participants were instructed to prevent a pendulum from swinging sideways. Dugdale and Eklund (2003) also found that dancers wobbled significantly more when instructed to avoid wobbling while counting backwards from 1000 in 7s than when given this instruction alone, and Bakker et al. (2006) found that participants directed their gaze to forbidden areas of a soccer goal even without a mental load, resulting in more missed penalty kicks than when gaze was not directed.



In contrast, de la Peña et al. (2008) found that instructions to avoid leaving the ball short or long in relation to the hole on their putting task actually produced significantly more over-compensatory movement (i.e. leaving the ball short when instructed to avoid leaving it long) than ironic effects. Similarly, Beilock et al. (2001) found that instructing participants to use suppressive imagery before putting (e.g. don't image the ball stopping short) induced more over-compensations (over-shots) than ironic outcomes. De la Peña and colleagues offer an implicit over-compensation hypothesis to explain these findings: negatively worded instructions exaggerate the importance of what must not be done, causing compensatory interpretations of target distance and location. The misconception that it is better to err in an over-compensatory way than in the forbidden way is then effected in movement to counteract the avoidant instruction. Given the methodological similarities it is not clear why these two studies produced errors in direct contradiction of more established ironic effects. It is postulated that a neglect to examine the consistency of individuals' error tendencies across trials and load conditions may be masking potentially important within participant variability in movement tendencies.



Wegner's theory explains a common observation among sport psychologists, coaches and athletes alike: high state anxiety, characterised by cognitive and/or autonomic system hyperactivity (Eysenck, 1997), reduces effective motor performance by diverting attention from task-relevant to task-irrelevant factors (Masters, 1992; Moran, 2003). State anxiety, as an emotional load, is hypothesised to diminish operating process efficiency, prompting the monitor to take control and shift attention toward unwanted thoughts, consequently priming the individual for ironic motor control. In turn, these ironic control failures further enhance accessibility to anxious thoughts and so perpetuate ironic results in a self-loading cyclic fashion. De la Peña et al. (2008) suggest that though a majority of over-compensations were observed in their putting task, those who made ironic movements may have experienced higher state anxiety. So far, though, the predictive power of state and trait anxiety for instruction induced movement errors has not been established.

In contrast to previous studies, the present study examined movement tendencies at the individual level, not the sample level. In line with Wegner's theory it was hypothesised that participants would make greater summed movement in directions they were specifically instructed to avoid (ironic error) than in directions opposite to those that were forbidden (over-compensatory error). This difference should be further pronounced when concurrently holding a seven-digit number in mind. Additionally, higher self-reported levels of state and trait anxiety were hypothesised to predict a consistent ironic movement tendency both with and without load.

## Method

*Participants and design*

Forty (eight male, 32 female, mean age=19 years, 1 month, SD=3yrs, 8 months) undergraduate Psychology students participated to gain course credit. All but one participant were right-handed and all had normal or corrected-to-normal vision. Local ethical approval was granted for this study. Participants completed the conditions of a 2 (Instruction type: with avoidant instruction vs. 'move straight' instruction only) x 2 (Mental load: without load vs. with load) x 4 (Movement direction: left vs. right vs. above vs. below) fully randomised within-groups design.

*Materials*

LabView 8.2 software recorded mouse positions at 200Hz and an analysis program calculated six kinematic variables per trial: mouse cursor movements from a target line (scores for left-right movements on vertical trials, above-below movements on horizontal trials); movement amplitude; duration; end-point positions; velocity; and peak velocity.

The Cognitive-Somatic Anxiety Questionnaire (CSAQ: Schwartz, Davidson, and Goleman, 1978) was used as a general self-report measure of trait cognitive and somatic anxiety, and the State-Trait Anxiety Inventory (STAI: Spielberger, 1983) was used in the state form (State Anxiety Questionnaire (SAQ)). The SAQ differed from the CSAQ in that it asked participants to rate the degree of anxious feelings experienced at the present moment, but Schwartz et al. (1978) found highly significant correlations between the cognitive and somatic components of the CSAQ and STAI ($r$=.67 and .40 respectively, $p$<.001).

*Procedure*

Participants completed the CSAQ and SAQ then proceeded to the task station. Participant and experimenter were seated either side of a partition with a 38cm Active Matrix LCD colour monitor, two speakers and wireless mouse on the participant's side, and a laptop with the experimental program on the experimenter's side. Participants viewed an on-screen circle, 22cm in diameter, with two opposing black dots positioned to indicate the end points of an invisible horizontal or vertical line running through the centre of the circle. It was emphasised that their primary objective at all times was to imagine the invisible straight line connecting the two dots and to move the mouse cursor back and forth between these dots, tracing the line as accurately as possible. They were asked to try to make approximately one movement per second moving in a steady, fluent rhythm, landing the mouse cursor on the dot before reversing, and that a program was recording their movement velocity and points of reversal to check this. They were also told they would receive additional instructions to avoid making specific movements on some blocks of trials; it was emphasised that obeying these instructions was of secondary importance to tracing the line accurately and that avoidant instructions were not feedback for performance on previous trials. Each trial lasted six seconds, trials were presented in blocks of six and two control and four experimental blocks were presented in each load condition.

During the two (control) blocks participants were instructed to 'move straight' and trace the line back and forth as accurately as possible prior to the start of each trial. Prior to four (experimental) blocks, participants were instructed to avoid making any mouse movements either to the left or right or above or below the invisible target line, with reminder instruction 'do not move to the left/right/above/below the line'. Only one direction was forbidden on any one trial (left or right when the target line was vertically oriented, above or below when the target line was horizontally oriented) and each direction was forbidden for one block in each load condition.

For the load condition, seven-digit numbers were randomly generated, displayed on-screen for seven seconds, prior to the trial block. Participants were instructed to continue tracing the line and avoid making forbidden movements (when instructed) as best they could while rehearsing this number in mind. The experimenter gave verbal feedback on their recall accuracy following each block to give the impression this was important to our investigation. Testing commenced once participants indicated they understood their instructions.



# Results

Three criteria were used to group each participant as either a consistent ironic, consistent over-compensatory or neutral performer. First, the greater of the ironic or over-compensatory summed movement scores indicated their initial grouping. Second, they remained in this group if their mean summed movement was more than two standard deviations from their mean summed movement score on 'move straight' (control) trials. Third, as a measure of consistency, they remained in this group if they exhibited the same error pattern on at least three out of four to-be-avoided directions. Failure to satisfy any one criterion resulted in grouping as a neutral performer.

Without load, these criteria produced 10 ironic performers, 26 over-compensatory performers, and four neutral performers. With load, criteria produced 12 ironic performers, 15 over-compensatory performers, and 13 neutral performers. Thus, the addition of the memory load produced a marked re-distribution of participants with less than half (*N*=19) remaining in the same group: 12 participants remained over-compensatory performers; one participant remained neutral; and, six remained ironic performers. The load-induced transfers of the remaining 21 participants were: over-compensatory to neutral (*N*=9); ironic to neutral (*N*=3); over-compensatory to ironic (*N*=5); ironic to over-compensatory (*N*=1); neutral to over-compensatory (*N*=2); and neutral to ironic (*N*=1). Due to these load-induced changes in behaviour, separate outcome, process, and predictor analyses were performed on data collected in each condition.

*Performance without load*

To check whether groups were performing similarly on 'move straight' trials, summed movement scores were analysed using a group (ironic, over-compensatory, neutral) X movement direction (left, right, above, below) mixed ANOVA. No significant main effect was found for group ($F$ (2, 37) =22.00, $p$=0.805, $\eta_p^2$=0.00), or movement direction ($F$ (3, 111) =1.68, $p$=0.175, $\eta_p^2$=0.04), and no significant interaction effect of group and movement direction was found ($F$ (6, 111) =0.76, $p$=0.600, $\eta_p^2$=0.04). Therefore, the summed deviation for performance on the control trials was subtracted from the summed deviation on the instruction trials, leaving errors associated with the instruction type. For example, when instructed to avoid moving left, subsequent leftward movement indicated an ironic effect whilst rightward movement indicated an over-compensatory effect. Additionally, since there were no significant directional biases during control trials, each set of means were collapsed to produce group means for the magnitude of ironic and over-compensatory movement as shown in Figure 1.

Insert Figure 1

A group (x3) X error type (ironic, over-compensatory) mixed ANOVA conducted on summed movement scores revealed participants made greater overall over-compensatory movement than ironic movement (21.51cm vs. 17.77cm, *SE*=5.24cm), however this difference was non-significant ($F$ (1, 37) =0.51, $p$=0.479, $\eta_p^2$=0.01). A significant interaction effect of group and error type was found, confirming the efficacy of the grouping criteria ($F$ (2, 37) =36.72, $p$=0.001, $p_{rep}$>0.99, $\eta_p^2$=0.67), with over-compensatory performers making significantly greater over-compensatory than ironic movement (51.23cm vs. 1.02cm, *SE*=4.94cm, $p$=0.001) whilst ironic performers made significantly greater ironic than over-compensatory movement (31.76cm vs. 8.14cm, *SE*=7.97cm, $p$=0.005).

Interestingly, the size of over-compensatory performers' mean over-compensatory movement was greater than that of ironic performers' mean ironic movement. As expected, a group (ironic, over-compensatory) X error type-group status consistency (consistent, inconsistent) ANOVA found no significant main effect for group ($F$ (1, 284) =1.80, $p$=0.180, $\eta_p^2$=0.01) and a large significant main effect of error-group consistency ($F$ (1, 284) =64.07, $p$=0.001, $p_{rep}$>0.99, $\eta_p^2$= 0.18). A significant interaction effect ($F$ (1, 284) =8.34, $p$=0.004,

$p_{rep}$=0.98, $\eta_p^2$= 0.03) confirmed that over-compensatory performers made significantly greater over-compensatory movement than ironic performers made ironic movement (51.23cm vs. 31.73cm, *SE*=6.52cm, $p$=0.003, $p_{rep}$=0.96). Results are summarised in Figure 2a.

Insert Figure 2



*Performance with load*

Since group *N*'s had changed a check to see if the new groups were still performing similarly on 'move straight' trials was conducted on summed movement scores. A group (x3) X movement direction (x4) mixed ANOVA showed no significant main effects for group ($F$ (2, 37) =2.51, $p$=0.095, $\eta_p^2$=0.12) or movement direction ($F$ (3, 111) =1.38, $p$=0.252, $\eta_p^2$=0.04), nor for a significant interaction effect ($F$ (6, 111) =0.73, $p$=0.624, $\eta_p^2$=0.04). Therefore, summed movements made on 'move straight' trials were again subtracted from summed movements on matched 'instruction' trials to indicate ironic and over-compensatory effects and means were collapsed across the direction conditions, as shown in Figure 1.

A group (x3) x error type (ironic, over-compensatory) mixed ANOVA performed on summed movement scores revealed a significant main effect for error type ($F$ (1, 37) =9.98, $p$=0.003, $p_{rep}$=0.98, $\eta_p^2$=0.21), with participants making greater over-compensatory movement than ironic movement (24.43cm vs. 13.70cm, *SE*=3.40cm), an effect which failed to reach significance without load. No significant main effect was found for group ($F$ (1, 284) =0.90, $p$=0.344, $\eta_p^2$=0.00), however, a significant interaction effect of group and error type ($F$ (2, 37) =51.31, $p$=0.001, $p_{rep}$>0.99, $\eta_p^2$=0.74) and large effect size again confirmed the efficacy of the grouping criteria. Over-compensatory performers made significantly greater over-compensatory than ironic movement (52.83cm vs. -2.21cm, *SE*=5.52cm, $p$=0.001), whilst ironic performers made significantly greater ironic than over-compensatory movement (36.45cm vs. 9.00cm, *SE*=6.18cm, $p$=0.001).

A group (ironic, over-compensatory) X error-group consistency (consistent, inconsistent) ANOVA again revealed a significant interaction effect ($F$ (1, 284) =14.48, $p$=0.001, $p_{rep}$>0.99, $\eta_p^2$=0.05), with over-compensatory performers making significantly greater over-compensatory movement than ironic performers made ironic movement (52.83cm vs. 33.38cm, *SE*=5.79cm, $p$=0.001). In addition, ironic performers made significantly greater over-compensatory movement compared to the ironic movement made by the over-compensatory performers (9.48cm vs. -2.21cm, *SE*=5.79cm, $p$=0.044). Results are summarised in Figure 2b.

*Kinematic analyses*

To investigate whether the errors being made could be accounted for by differences in speed or accuracy, various properties of participants' movements were analysed. These were: mean movement amplitude; duration; consistency (standard deviations around endpoint positions); velocity; and peak velocity. A series of group (x3) X instruction (x2) mixed ANOVAs were performed separately on data collected during the 'without load' and 'with load' conditions. Results are summarised in Table 1.

Insert Table 1

Without load, no significant main or interaction effects were found for endpoint variability, mean movement velocity, or mean peak velocity. A significant interaction effect of group and instruction was found for mean movement duration, with neutral performers completing movements significantly faster when instructed to move straight than when given avoidant instruction (1.04s vs. 1.17s, *SE*=0.06s, $p$=0.029, $p_{rep}$=0.93). A significant main effect of group was found for mean movement amplitude, with post-hoc Tukey HSD indicating that neutral performers' made significantly larger movement than the ironic performers (21.92cm vs. 21.16cm, *SE*=0.20, $p$=0.005). With load, the only significant finding was a significant main effect of group on endpoint variability; however, post-hoc Tukey HSD found the difference between over-compensatory and neutral performers to be non-significant (0.37 vs. 0.54, *SE*=0.74, $p$=0.062).

*State and trait anxiety as predictors of group status*

Without load, comparing the groups on the cognitive and somatic anxiety subscales of the CSAQ and on the SAQ revealed that ironic performers reported greater trait cognitive anxiety (*M*=24.00, *SD*=3.80); trait somatic anxiety (*M*=14.80, *SD*=5.29); and state anxiety (*M*=45.30, *SD*=7.85) than over-compensatory performers (cognitive, *M*=18.35, *SD*=4.35; somatic, *M*=10.19, *SD*=3.35; and, state, *M*=39.58, *SD*=5.79). Independent *t*-tests confirmed these differences to be significant (cognitive: $t$ (34) = -3.61, $p$=0.001, $p_{rep}$>0.99, $d$=1.38; somatic: $t$ (34) = -3.13, $p$=0.004, $p_{rep}$=0.95, $d$=0.95; state: $t$ (34) = -2.40, $p$=0.022, $p_{rep}$=0.95, $d$=0.78).

After removing neutral performers, Pearson's correlation tests indicated that scores on the CSAQ-cognitive subscale were significantly correlated with scores on the CSAQ-somatic subscale ($r$=0.63, $p$=0.001, $p_{rep}$>0.99) and the SAQ ($r$=0.39, $p$=0.019, $p_{rep}$=0.95); however, the CSAQ-somatic subscale was not significantly correlated with the SAQ ($r$=0.26, $p$=0.131). A backward stepwise logistic regression analysis was performed with scores on the CSAQ-somatic and SAQ entered as predictor variables and group status (ironic, over-compensatory) as the criterion variable. The full model significantly predicted group status ($\chi^2$ (2) =14.83, $p$=0.001, $p_{rep}$>0.99, $R^2$=0.37 (Homer & Lemeshow)). Overall, 80% of predictions were accurate; 92.3% of over-compensatory performers were accurately predicted, however only 44.4% of ironic performers were accurately predicted. Results summarised in Table 2 show that only CSAQ-somatic score significantly predicted group status without load, with each unit increase on the CSAQ-somatic subscale increasing the odds of being an ironic performer by a factor of 1.34.

Insert Table 2

Despite group changes with load, ironic performers again reported greater trait cognitive anxiety ($M$=20.17, $SD$=5.02); trait somatic anxiety ($M$=12.58, $SD$=5.52); and state anxiety ($M$=43.08, $SD$=6.91) than over-compensatory performers (cognitive, $M$=18.93, $SD$=5.18; somatic, $M$=10.67, $SD$=3.72; and state, $M$=38.20, $SD$=7.48). However, independent $t$-tests found these differences to be non-significant (cognitive: $t$ (25) = -0.62, $p$=0.539; somatic: $t$ (25) = -1.01, $p$=0.292; state: $t$ (25) = -1.74, $p$=0.094).

Pearson's correlation tests showed similar results to those observed without load (CSAQ-cognitive and CSAQ-somatic, $r$=0.70, $p$=0.001, $p_{rep}$>0.99; CSAQ-cognitive and SAQ, $r$=0.46, $p$=0.016, $p_{rep}$=0.94; CSAQ-somatic and SAQ $r$=0.30, $p$=0.125). Therefore, the same backward stepwise logistic regression analysis was performed, with CSAQ-somatic and SAQ score entered as predictor variables and group status as the criterion variable. The final model did not significantly predict group status (Step 1: $\chi^2$ (2) =3.50, $p$=0.174, $R^2$=0.09 (Homer & Lemeshow); Step 2: $\chi^2$ (1) =3.09, $p$=0.079, $R^2$=0.08 (Homer & Lemeshow)). Results summarised in Table 3 show that neither CSAQ-somatic score nor SAQ score significantly predicted group status with load.

Insert Table 3

## Discussion

Ironic effects and over-compensations are not experienced as general phenomena, but rather, avoidant instructions induce both ironic and over-compensatory movements differently between and within individuals. Without the memory load, more participants consistently made over-compensatory movements than ironic movements when instructed to avoid making specific directional movements. However, a considerable migration away from consistent over-compensation toward a roughly even redistribution of participants across the three performance groups was observed when the memory load was added to their task. This pattern of change in movement tendency across load conditions suggests low load levels are not necessarily associated with accurate/intentional motor control as Wegner hypothesises, but may actually promote over-compensatory movement as the dominant error type. In short, neither the ironic processing theory nor implicit over-compensation hypothesis alone explain the movement errors people make when warned against making particular errors; alternatively, ironic and over-compensatory movements appear to be cognitive load-induced in some individuals and load-independent, trait-like responses in others. The hypothesis that the latter individuals' response tendencies reflect a broader cognitive style certainly warrants investigation. That ironic and over-compensation groups performed similarly along the majority of kinematic variables recorded supports the view that movement error differences were not related to differences in speed or endpoint accuracy.

The magnitude of over-compensatory error made by over-compensatory performers was significantly greater than the magnitude of ironic error made by ironic performers, both with and without the memory load. However, whilst the magnitude of error remained similar between conditions, the memory load removed error tendencies in 30% of participants, promoted errors in 7.5% and switched error tendencies in 15%. Wegner contends that increasing mental load during attempts to avoid specific movement should magnify ironic effects, and whilst this was the case for a small number of participants the results show that cognitive load influenced people in a variety of ways. These findings lend more support to the implicit over-compensation hypothesis but are not entirely incongruent with Wegner's two-process model: for a small number of participants the memory load may indeed have reduced the operating process' ability to focus attention on moving in straight lines, allowing the monitor to sensitise attention to thoughts of forbidden movements. Though the avoidance of particular movements was emphasised to participants as a goal secondary to that of moving in straight lines, it appears that the memory load heightened their susceptibility to ironic errors which, in turn, exaggerated the importance of avoiding ironic movements. In disregarding what they were told at the outset, participants ultimately worked their way into error.

De la Peña et al. (2008) suggested that the participants who made ironic movements might have suffered from greater levels of anxiety than those who over-compensated. In support of this, ironic performers without load reported significantly greater levels of trait cognitive, trait somatic, and state anxiety, and somatic anxiety scores significantly predicted participants' consistent movement tendency. Group differences in anxiety levels became non-significant when the memory load was added and somatic scores failed to continue to predict group status, although this may have been partly due to changes in group status. As anxiety has been positively associated with a tendency to suppress unwanted thoughts (Wegner & Zanakos, 1994; Becker et al., 1998), it has been postulated that anxiety should be associated with greater ironic error (Wegner, 1994). Indeed, higher levels of anxiety did seem to compel ironic error, but this was not the most prevalent or detrimental error type. The fact the large over-compensatory errors were made by the less anxious individuals suggests a modification of Wegner's two-process model to emphasise the association of low anxiety levels and over-compensatory error as more important in terms of motor performance than the association between high anxiety levels and ironic error. Thus, while anxiety is traditionally thought to destabilise performance, it seems that increased levels of trait and state anxiety actually benefited the overall performance of many individuals here.

The avoidant instructions used here deliberately resembled those regularly used by coaches to direct their athletes and by athletes in their self-talk to show how ironic outcomes and over-compensations can be unwittingly inflicted in sporting contexts. For laboratory studies, too, results indicate a potential for avoidant instructions to be the very reason why participants fail to perform their tasks well. By extension, what experimenters often assume to be random error in their data may actually be explained by ironic and over-compensatory responding styles. In any event, experimenters may minimise their biasing influence by emphasising to participants what is to be achieved while neglecting to specify what should be avoided.

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**Table Captions.**

Table 1. Results of separate 2 x 2 ANOVAs performed on six kinematic dependent variables recorded during each load condition.

Table 2. Summary of backward stepwise logistic regression performed on group status without a memory load.

Table 3. Summary of backward stepwise logistic regression performed on group status with a memory load.

Table 1.

| DV | IV (Without load/With load) | ANOVA summary |
|---|---|---|
| Amplitude | Group (without load) | $F$ (2, 37) =5.81, $p$ =0.006, $p_{rep}$=0.98, $\eta_p^2$=0.24 |
| | Group (with load) | $F$ (2, 37) =1.40, $p$ =0.260, $\eta_p^2$=0.07 |
| | Instruction (without load) | $F$ (1, 37) =1.04, $p$ =0.313, $\eta_p^2$=0.03 |
| | Instruction (with load) | $F$ (1, 37) =0.03, $p$ =0.856, $\eta_p^2$=0.00 |
| | Group*Instruction (without load) | $F$ (2, 37) =0.69, $p$ =0.509, $\eta_p^2$=0.04 |
| | Group*Instruction (with load) | $F$ (2, 37) =1.46, $p$ =0.246, $\eta_p^2$=0.07 |
| Duration | Group (without load) | $F$ (2, 37) =0.96, $p$ =0.394, $\eta_p^2$=0.05 |
| | Group (with load) | $F$ (2, 37) =0.14, $p$ =0.868, $\eta_p^2$=0.01 |
| | Instruction (without load) | $F$ (1, 37) =1.31, $p$ =0.259, $\eta_p^2$=0.03 |
| | Instruction (with load) | $F$ (1, 37) =0.01, $p$ =0.924, $\eta_p^2$=0.00 |
| | Group*Instruction (without load) | $F$ (2, 37) =3.34, p=0.046, $p_{rep}$=0.96, $\eta_p^2$=0.15 |
| | Group*Instruction (with load) | $F$ (2, 37) =0.34, $p$ =0.714, $\eta_p^2$=0.02 |
| SD around end points | Group (without load) | $F$ (2, 37) =0.85, $p$ =0.436, $\eta_p^2$=0.04 |
| | Group (with load) | $F$ (2, 37) =3.25, $p$ =0.050, $p_{rep}$=0.96, $\eta_p^2$=0.15 |
| | Instruction (without load) | $F$ (1, 37) =0.82, $p$ =0.373, $\eta_p^2$=0.02 |
| | Instruction (with load) | $F$ (1, 37) =0.04, $p$ =0.840, $\eta_p^2$=0.00 |
| | Group*Instruction (without load) | $F$ (2, 37) =0.07, $p$ =0.932, $\eta_p^2$=0.00 |
| | Group*Instruction (with load) | $F$ (2, 37) =1.37, $p$ =0.266, $\eta_p^2$=0.07 |
| Velocity | Group (without load) | $F$ (2, 37) =2.92, $p$ =0.066, $\eta_p^2$=0.14 |
| | Group (with load) | $F$ (2, 37) =0.40, $p$ =0.672, $\eta_p^2$=0.02 |
| | Instruction (without load) | $F$ (1, 37) =0.53, $p$ =0.472, $\eta_p^2$=0.01 |
| | Instruction (with load) | $F$ (1, 37) =0.78, $p$ =0.383, $\eta_p^2$=0.02 |
| | Group*Instruction (without load) | $F$ (2, 37) =2.02, $p$ =0.147, $\eta_p^2$=0.10 |
| | Group*Instruction (with load) | $F$ (2, 37) =0.09, $p$ =0.916, $\eta_p^2$=0.01 |
| | Group (without load) | $F$ (2, 37) =2.16, $p$ =0.130, $\eta_p^2$=0.10 |
| | Group (with load) | $F$ (2, 37) =1.25, $p$ =0.298, $\eta_p^2$=0.06 |

| | | |
|---|---|---|
| Peak velocity | Instruction (without load) | $F$ (1, 37) =0.10, $p$ =0.758, $\eta_p^2$=0.00 |
| | Instruction (with load) | $F$ (1, 37) =0.01, $p$ =0.946, $\eta_p^2$=0.00 |
| | Group*Instruction (without load) | $F$ (2, 37) =2.53, $p$ =0.093, $\eta_p^2$=0.12 |
| | Group*Instruction (with load) | $F$ (2, 37) =1.51, $p$=0.748, $\eta_p^2$=0.02 |

Table 2.

| | Included | B (SE) | Wald | *p* | exp (β) | 95% CI |
|---|---|---|---|---|---|---|
| Step 1 | CSAQ-Somat. | 0.29 (0.13) | 5.29 | 0.021 | 1.34 | 1.04-1.71 |
| | SAQ | 0.19 (0.10) | 3.50 | 0.062 | 1.21 | 0.99-1.48 |
| | Constant | -12.81 (5.00) | 6.56 | 0.010 | 0.00 | |

Table 3.

| | Included | B (SE) | Wald | *p* | exp (β) | 95% CI |
|---|---|---|---|---|---|---|
| Step 1 | CSAQ-Somat. | 0.06 (0.09) | 0.41 | 0.524 | 1.06 | 0.99-1.27 |
| | SAQ | 0.09 (0.07) | 2.01 | 0.156 | 1.10 | 0.97-1.25 |
| | Constant | -4.65 (2.69) | 3.00 | 0.084 | 0.01 | |
| Step 2 | SAQ | 0.10 (0.06) | 2.59 | 0.108 | 1.11 | 0.98-1.25 |
| | Constant | -4.32 (2.59) | 2.79 | 0.095 | 0.01 | |

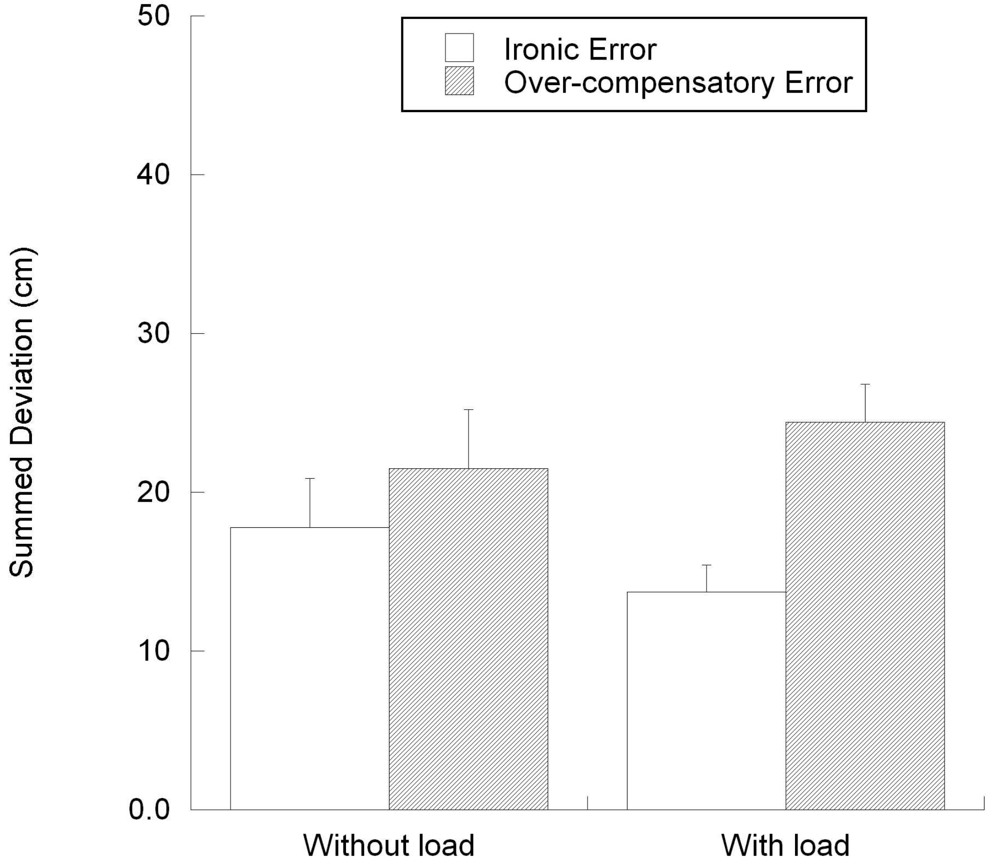


Figure 1. Mean ironic and over-compensatory error made with and without a memory load. Error bars indicate standard errors.
160x141mm (288 x 288 DPI)

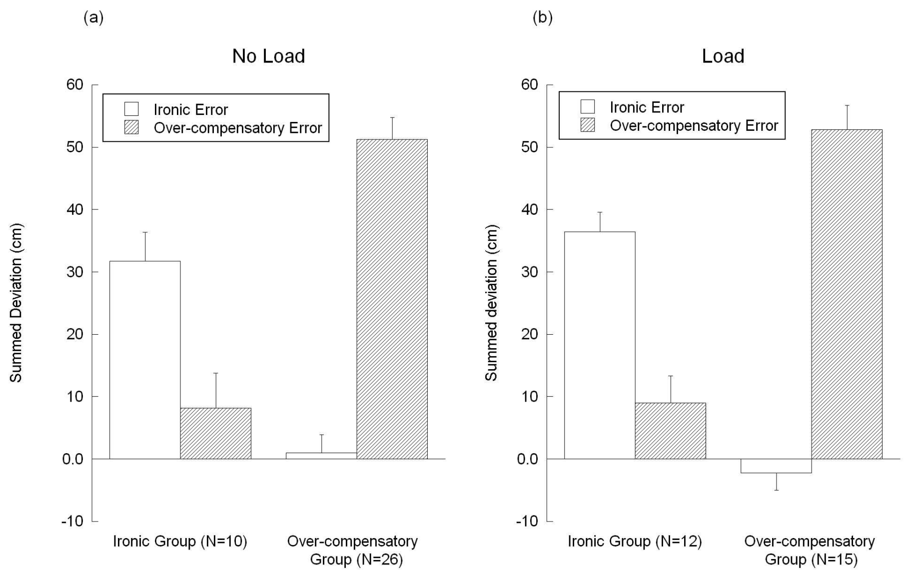


Figure 2 (a). Mean ironic and over-compensatory error made by ironic and over-compensatory groups without a memory load, and (b) with memory load. Error bars indicate standard errors.
188x126mm (288 x 288 DPI)