# Comparing the effects of conscious monitoring and conscious control on motor performance

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**Abstract**

We compared the effects of conscious monitoring and control on motor performance. Participants were instructed to adopt an internal or external focus of attention in different blocks of a darts task. For one group, the internal as well as external focus instructions emphasized monitoring. For another group, the instructions emphasized control in the two focus conditions. Furthermore, participants' propensity for monitoring and control was gauged via two factors of the Movement Specific Reinvestment Scale (MSRS) (Masters, Eves, & Maxwell, 2005). These factors were Movement Self-Consciousness (MS-C) and Conscious Motor Processing (CMP), which measure propensity for conscious monitoring and control, respectively. Performance differences between the internal and external focus blocks were expressed as mean radial error (MRE). Results revealed a 3-way interaction between CMP, instruction type (monitoring versus control) and an order effect. Only in the conscious control-group, but not the conscious monitoring-group was there a 2-way interaction between CMP and order. In the conscious control-group, participants with high CMP scores showed worse performance in whichever focus block (internal or external) was presented last. There were no significant effects in the monitoring-group or of MS-C. These findings indicate that conscious control has a stronger effect on motor performance than conscious monitoring.

## Introduction

Conscious attention plays an important role in motor performance. The theory of reinvestment (Masters, 1992; Masters & Maxwell, 2008), explicit monitoring theory (Beilock, 2011; Beilock & Carr, 2001) and the constrained action hypothesis (Wulf & Lewthwaite, 2010; Wulf, McNevin, & Shea, 2001) all agree that attention to movement execution decreases automaticity. Consequently, such an internal focus of attention may disrupt motor learning and performance (e.g. Beilock, 2011; Masters, 1992; Wulf et al., 2001).

Even though generally described as negative, internal foci may also carry positive effects. For example, a recent study by Zhang et al. (2016) found that mindfulness – described as "the clear and single-minded awareness of what actually happens to us and in us" (Nyanaponika Thera, 1972, p. 5) – positively affected learning of a darts throwing task. This finding raises the question of what makes some internal foci distruptive to performance and others beneficial.

The effect of internally focused attention may depend on its relative emphasis on conscious monitoring or control. Where mindfulness exclusively involves monitoring – i.e., "a bare display of what is taking place" (Shear & Jevning, 1999, p. 204) – other forms of internal focus may involve an added desire to control – i.e., 'manipulation of conscious, explicit, rule based knowledge, by working memory, to control the mechanics of one's movements during motor output' (Masters & Maxwell, 2004, p. 208). When monitored, movements are exclusively observed, but not necessarily influenced, whereas when controlled they are observed as well as influenced[1].

[1] Monitoring and control should therefore *not* be viewed as mutually exclusive. Rather, conscious control includes monitoring. Control also infers an attempt to influence movements, whereas monitoring does not.

One method of investigating monitoring and control is via verbal instructions. Even though previous studies have primarily used verbal instructions to manipulate conscious control, it may also be possible to manipulate monitoring. For example, using a darts task, Lohse, Sherwood, and Healy (2010) instructed participants "Each time you throw, focus on [your arm/the dart] and think about [how you are moving/how it should fly]". By slightly altering these instructions – e.g., by changing "think about [how you are moving/how it should fly]" into "be aware of how it [moves/flies]" – it may be possible to manipulate conscious monitoring, without incurring attempts to influence ongoing movements.

A second way to investigate monitoring and control may be to compare how two factors of the Movement Specific Reinvestment Scale (MSRS) (Masters, Eves, & Maxwell, 2005) relate to motor performance. These are Movement Self-Consciousness (MS-C) and Conscious Motor Processing (CMP). Using laparoscopic surgery training tasks (Malhotra, Poolton, Wilson, Fan, and Masters (2014); Malhotra, Poolton, Wilson, Leung, et al. (2015) or golf-putting (Malhotra, Poolton, Wilson, Omuro, & Masters, 2015; Malhotra, Poolton, Wilson, Uiga, & Masters, 2015) studies have found that the two factors of the MSRS have differential effects on motor learning and performance. These findings imply that MS-C and CMP reflect predispositions for different types of internally focused attention. People with high MS-C scores may be more inclined to consciously monitor their movements, while those with high CMP scores may be more inclined to consciously monitor and control their movements.

Whether MS-C and CMP delineate conscious monitoring and control is somewhat of an open question. The MS-C factor (see Appendix A) emphasizes observing one's movements – e.g. "I sometimes have the feeling that I am watching myself move", whereas the CMP factor emphasizes further engagement with these observations – e.g. "I reflect about my movements a lot". That is, MS-C more closely resembles the predisposition for conscious monitoring, while CMP more closely resembles the predisposition for conscious control.

In order to verify whether MS-C and CMP delineate propensities for conscious monitoring and control we compared them to a gold-standard – the Mindful Attention Awareness Scale (MAAS) (Brown & Ryan, 2003) (see Appendix B) – and we investigated whether they influence participants' preference for either internal or external foci. The MAAS measures mindfulness and can therefore be used to verify whether MS-C (and not CMP) reflects propensity for conscious monitoring. Furthermore, participants rated their ability to sustain internal and external foci and whether these disturbed their performance. Congruence between predispositions and instructions was expected to increase sustainability and decrease perceived disturbance.

Subsequently, we combined verbal instructions and personality predispositions to investigate whether conscious monitoring and control have different effects on motor performance. It was expected that performance differences between internal and external foci would be greater when instructions emphasized conscious control rather than monitoring. Furthermore, this effect was expected to be more pronounced for participants with high CMP scores, because their high conscious control propensity was expected to increase the extent to which they engage in conscious control when instructed to do so. By contrast, MS-C and MAAS scores were not expected to act as moderators or to do so less strongly than CMP.

## Methods

**Ethics.** Ethical approval was requested with and granted by the university's research ethics committee.

**Participants.** Forty-six undergraduate university students (24 male, 22 female; age $M$ = 21.3, $SD$ = 1.8 years) were rewarded course credits for their participation in the experiment. They had normal or corrected to normal vision and limited darts playing experience – i.e. none of them played or had ever played darts more frequently than once per month. They were

randomly assigned to a conscious monitoring group (*N* = 23, 10 male, 13 female; age *M* = 21.3, *SD* = 1.7 years) and a conscious control[2] group (*N* = 23, 14 male, 9 female; age *M* = 21.3, *SD* = 1.9 years).

**Apparatus**. A dart board of standard size and height (bulls-eye 1.73m from the ground) and 3 standard darts were used. A line of adhesive tape marked the standard throwing distance to the dart board – 2.37 meter. To record landing positions of the darts, a Panasonic 3CCD HD video camera captured a frontal view of the dartboard from a vantage point at a height of 2.5 meters and 2 meters behind the participant. Video images were processed using Matlab version 2012a. Statistical analyses were carried out using IBM SPSS Statistics Version 20. An MSRS (Masters et al., 2005) was used to capture MS-C and CMP scores and a MAAS to capture mindfulness (Brown & Ryan, 2003)

**Procedure.** Participants received a verbal explanation of the procedure and, after signing informed consent, they were positioned behind the throwing line with their feet and shoulders aligned parallel with the direction to the target. Participants adopted this position throughout the experiment. They were granted three practice throws to familiarize themselves with the task.

All participants performed 4 blocks of 45 throws each, aiming at the bulls-eye. As in regular matchplay darts, they used a set of three darts, which they removed from the board themselves after every 3rd throw. In the first block, participants were not given any instructions. Before the second and third block, they received focus instructions (see Appendix C) adapted from Lohse et al. (2010), which were designed to manipulate focus of attention (internal versus external) as well as attention quality (monitoring versus control). In a conscious monitoring group, the internal and external focus instructions emphasized that participants should be aware

[2] Not to be confused with a vernacular control group.

of their arm movements or of the flight of the dart, respectively. In a conscious control group, the internal and external focus instructions emphasized that participants should attempt to produce a pre-determined ideal arm movement or ideal dart flight, respectively. The order of the internal and external focus blocks was counterbalanced between- and randomized within groups.

During the blocks, participants received brief, verbal reminders of the relevant instructions. These reminders were provided after every 6$^{th}$ throw when they were removing their darts from the board. After the second and third block, participants completed visual rating scales (see Appendix C) regarding how well they were able to sustain the instructed focus and whether the focus disturbed their performance by indicating a position on a 10cm line that ranged from 'not at all' to 'very much'. The fourth and final block was identical to the first block, such that no instructions were provided. After the fourth block, participants indicated on a 10cm line ranging from 'completely internal' to 'completely external' whether the focus they had adopted in the first block and then in the fourth block was relatively more similar to the internal or external focus condition (see Appendix C). During the final part of the experiment, participants completed the MSRS (Masters et al., 2005), the MAAS (Brown & Ryan, 2003) and were verbally debriefed.

**Data handling and statistics.** Internal consistency of the MAAS, MSRS and its subscales was determined based on the Crohnbach's alpha statistic. A linear regression was calculated to evaluate the associations between the MAAS and the MS-C and CMP subscales of the MSRS. As MS-C and the MAAS may reflect the same construct – conscious monitoring propensity – each analysis involving conscious control propensity was carried out twice: Once using MS-C and once using the MAAS. Whether MS-C or MAAS was used only marginally changed the effects of other variables. Therefore, the reported results are those using MS-C scores.

Performance was expressed as mean radial error (MRE), with lower MRE indicating better performance. The performance difference between the internal and external focus blocks served as main outcome.

The effects of the instructions (monitoring versus control), the two factors of the MSRS, the MAAS, the order (internal block first versus external block first) as well as their interactions were tested using a stepwise multiple linear regression. The stepwise method was chosen, because the number of potential effects (4 main effects, 6 two-way interactions, 4 three-way interactions and 1 four-way interaction) was large. Effects on the ability to sustain the instructed focus of attention, perceived performance disturbance and focus of attention adopted in the first and last block we tested by multiple linear regressions using the enter method.

## Results

**Questionnaires.** Except for 2 participants, who did not complete the MAAS, all participants completed both questionnaires. On average, participants answered between "weakly disagree" and "weakly agree" on the MSRS – MS-C ($M$ = 3.74, $SD$ = 1.01), CMP (M = 3.72, $SD$ = .97) – and between "somewhat frequently" and "somewhat infrequently" on the MAAS ($M$ = 3.82, $SD$ = .59). There were no significant differences in MS-C, CMP or MAAS-scores between the conscious monitoring and the conscious control group ($ps$ > .51).

The internal consistency of the MAAS was acceptable to good (α = .802), as was that of the MSRS (α = .811) and its subscales MS-C (α = .788) and CMP (α = .772). MS-C and CMP showed a significant association (β = .33, $t(44) = 2.30$, $p$ = .03, $sr^2$ = .10). A linear regression revealed that a model including MS-C and CMP significantly predicted MAAS scores ($F(2, 41) = 3.83$, $p$ = .03, $R^2$ = .16). However, only MS-C (β = .34, $t(41) = 2.24$, $p$ = .03, $sr^2$ = .10) was significantly associated with MAAS score, while CMP was not (β = .13, $t(41)$ = .89, $p$ = .38, $sr^2$ = .02).

**Subjective experiences.** In the first and the last block, higher CMP scores were associated with a tendency to adopt an internal rather than an external focus of attention. In the first block, CMP had a marginally significant effect on the focus that participants naturally adopted (β = -.28, $t(43) = -1.85$, $p = .07$, $sr^2 = .07$), whereas neither MS-C (β = -.17, $t(43) = -1.11$, $p = .27$, $sr^2 = .02$) nor the MAAS (β = -.03, $t(43) = -.17$, $p = .86$, $sr^2 < .001$) had an effect. In the last block, CMP had a significant effect on focus (β = -.32, $t(43) = -2.07$, $p = .04$, $sr^2 = .09$), whereas MS-C (β = -.001, $t(43) = -.006$, $p = .99$, $sr^2 < .001$) and the MAAS (β = .08, $t(43) = .51$, $p = .61$, $sr^2 < .01$) still had no effect. Except for a marginally significant effect of CMP on participants' perceived ability to sustain an external focus of attention (β = -.27, $t(43) = -1.76$, $p = .09$, $sr^2 = .06$) – whereby higher CMP scores were associated with a decreased ability to sustain an external focus – no significant effects were found of MS-C, CMP or the MAAS on perceived ability to sustain or disturbance by internal or external foci.

**Performance.** Stepwise linear regressions with MRE difference between internal and external focus as dependent variable and with MS-C (or the MAAS), CMP, instruction type (monitoring versus control), order and their interactions as predictors revealed a 3-way interaction between CMP, instruction type and order ($F(1, 44) = 4.59$, $p = .04$, $R^2 = .10$), (β = .31, $t(44) = 2.14$, $p = .04$, $r^2 = .10$) (see Figure 1). None of the other variables significantly predicted the performance difference between internal and external focus (*ps* > .10).

Further exploration of the 3-way interaction revealed a 2-way interaction between CMP score and order (β = .70, $t(21) = 4.54$, $p < .001$, $sr^2 = .50$) in the conscious control group, but not the conscious monitoring group (β = .03, $t(21) = .15$, $p = .88$, $sr^2 < .01$). Under instructions that emphasized conscious control, participants with higher CMP scores tended to perform better in whichever focus of attention condition (internal or external) occurred first, and worse in whichever focus occurred last. If the internal focus block occurred first, CMP scores were

associated with better performance in the internal compared to the external focus condition (β = .66, $t(10) = 2.76$, $p = .02$, $sr^2 = .43$). Conversely, if the external focus block occurred first, CMP scores were associated with better performance in the external compared to the internal focus condition (β = -.79, $t(9) = -3.80$, $p = .004$, $sr^2 = .62$).

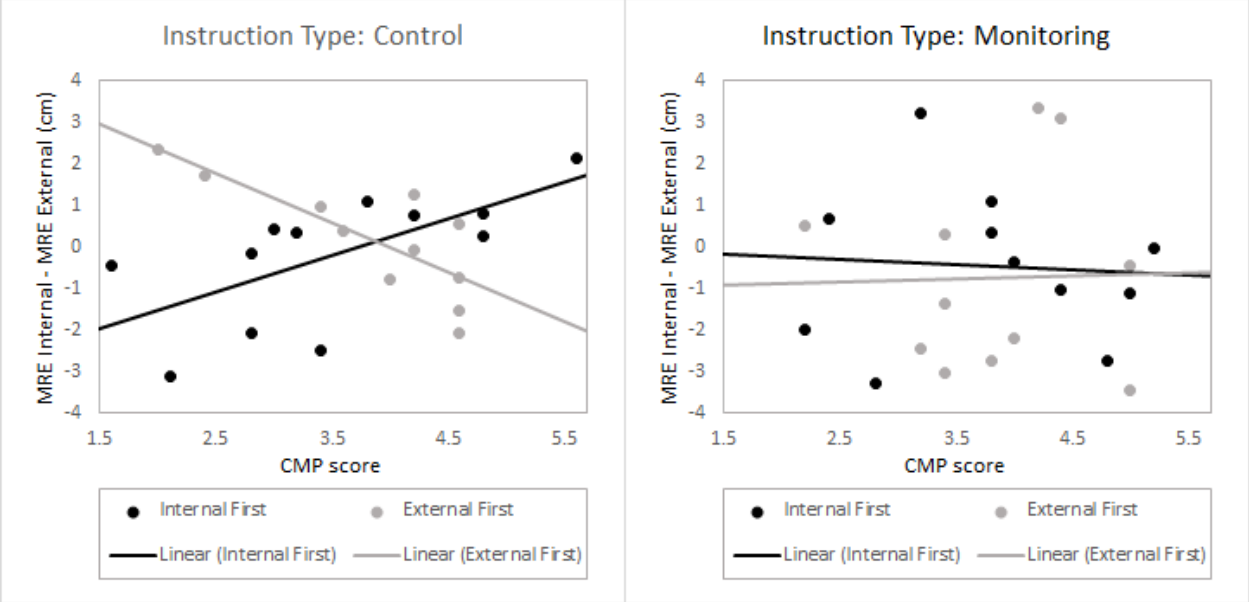


Fig. 1. The 3-way interaction between CMP, instruction type and order. Higher MRE difference between internal and external focus corresponds with a better performance in the internal focus block.

## Discussion

We investigated the effects of conscious monitoring and control on the performance differences between internal and external foci. To this end, novice participants engaged in a darts task in which they were instructed to adopt an internal and external focus of attention in different blocks. One group received the internal and external focus instruction with an emphasis on conscious monitoring, whereas the emphasis of the other group's instructions was on conscious control. Monitoring and control were furthermore observed using two factors of the MSRS (Masters et al., 2005) – MS-C and CMP, which were thought to operationalize propensity for conscious monitoring and control, respectively. This ability of the MS-C and

CMP factors to delineate propensities for conscious monitoring and control was scrutinized by comparing their associations to the MAAS (Brown & Ryan, 2003) as well as a number of subjective experiences regarding: preferred focus, the ability to sustain foci and perceived disturbance to performance.

The comparisons of the MSRS to the MAAS as well as the subjective experiences provided some indication that MS-C – rather than CMP – reflects the propensity for conscious monitoring and that CMP – rather than MS-C or the MAAS – may reflect the propensity for conscious control. In particular, the finding that MS-C correlates significantly with MAAS scores – whereas CMP does not – indicates that MS-C reflects an ability to be self-aware without necessarily intervening. That said, it should be acknowledged that the association between MS-C and the MAAS was relatively weak, indicating that no conclusive inference can be made. Furthermore, the fact that MS-C and CMP showed a weak association with each other indicates that the two factors are not entirely separate and suggests that CMP partially captures conscious monitoring as well as a desire to interfere in the control of movements. In line with this conjecture, the subjective experience measures indicated that CMP had a larger influence than MS-C on the ability to sustain and the preference for an internal focus. Although these results do not provide irrevocable proof, they do resonate with the notion of Malhotra, Poolton, Wilson, Omuro, et al. (2015), Malhotra, Poolton, Wilson, Uiga, et al. (2015), Malhotra, Poolton, Wilson, Leung, et al. (2015) and Malhotra et al. (2014) that MS-C reflects monitoring, whereas CMP reflects conscious control.

Surprisingly, the effects of control (i.e., conscious control instructions and CMP scores) interacted with the order in which the instructions were presented, rather than - as was expected - a preference for an internal focus of attention regardless of order. This finding has multiple possible explanations. Given that conscious control is based on ‘manipulation of conscious, explicit, rule based knowledge’ (Masters & Maxwell, 2004), it may be speculated that the

knowledge used for conscious control differs between internal and external foci. As a result, in the second focus block: (1) extra effort or time may have been needed to replace knowledge from the first focus block; (2) cumulative knowledge accrual may have increased the burden on working memory capacity; (3) old and new knowledge may have contracted or conflicted with each other; (4) mental fatigue may have depleted participants' cognitive resources after an extended period of manipulating knowledge in the first block. As these explanations are not mutually exclusive, they may all partially explain the order effect. Needless to say that the scope of this study does not afford definite conclusions regarding the nature of the order effect.

Regardless of the unexpected manner in which motor performance was influenced, it remains the case that conscious control - and not conscious monitoring - exerted this influence. CMP and conscious control instructions interacted to predict whether performance would drop in the second focus block. By contrast, neither MS-C nor the monitoring instructions showed significant effects. In line with Malhotra, Poolton, Wilson, Leung, et al. (2015), the results of this study therefore indicate that conscious control had a more pronounced influence on motor performance than conscious monitoring.

In conclusion, results of the current study suggest that conscious monitoring and conscious control are two different types of internally focused attention, with different effects on motor performance. This notion is supported not only by the effects of personality predispositions and verbal instructions separately, but by a convergence between the two. While monitoring leaves motor performance unaffected – or may sometimes even influence it positively (Zhang et al., 2016) – conscious control appears to disrupt motor performance, as predicted by the theory of reinvestment (Masters & Maxwell, 2008), explicit monitoring theory (Beilock & Carr, 2001) and the constrained action hypothesis (Wulf & Lewthwaite, 2010).

This study opens multiple avenues for further study. For example, the study only included novice participants. As the immediate effects of attentional focus may depend on expertise (Perkins-Ceccato, Passmore, & Lee, 2003), further research is necessary to determine the effects of conscious monitoring and control in experts. To follow-up on the surprising order-effect, the burden on working memory caused by switching attentional focus could be investigated using secondary-tasks (Masters, 1992; Maxwell, Masters, & Eves, 2000). Furthermore, replication studies are needed to validate whether verbal instructions can distinctively induce monitoring and control. Verbal protocols – methods for determining criterion validity of verbal instructions (e.g. Liao & Masters, 2001; Maxwell, Masters, & Poolton, 2006) – could not be used in this study, as they assess the amount of verbal knowledge used in a motor task, not the exact nature of this knowledge. Future work could employ brain imaging techniques (e.g., EEG, NIRS) to provide a more objective verification of instructions designed to manipulate focus of attention. The weak correlation between MS-C and CMP also suggests that the factors discriminant validity can be improved. Lastly, it would be reassuring to know that the confluence of personality predispositions and conscious control manipulations is replicable.

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## THE MOVEMENT SPECIFIC REINVESTMENT SCALE



**Name:** _____ **Date:** _____ **Age:** _____ **Hand: L / R**

**DIRECTIONS: Below are a number of statements about your movements. The possible answers go from 'strongly agree' to 'strongly disagree'. There are no right or wrong answers so circle the answer that best describes how you feel for each question.**

**1 I rarely forget the times when my movements have failed me, however slight the failure.**

strongly disagree | moderately disagree | weakly disagree | weakly agree | moderately agree | strongly agree

**2 I'm always trying to figure out why my actions failed.**

strongly disagree | moderately disagree | weakly disagree | weakly agree | moderately agree | strongly agree

**3 I reflect about my movement a lot.**

strongly disagree | moderately disagree | weakly disagree | weakly agree | moderately agree | strongly agree

**4 I am always trying to think about my movements when I carry them out.**

strongly disagree | moderately disagree | weakly disagree | weakly agree | moderately agree | strongly agree

**5 I'm self conscious about the way I look when I am moving.**

strongly disagree | moderately disagree | weakly disagree | weakly agree | moderately agree | strongly agree

**6 I sometimes have the feeling that I'm watching myself move.**

strongly disagree | moderately disagree | weakly disagree | weakly agree | moderately agree | strongly agree

**7 I'm aware of the way my mind and body works when I am carrying out a movement.**

strongly disagree | moderately disagree | weakly disagree | weakly agree | moderately agree | strongly agree

**8 I'm concerned about my style of moving.**

strongly disagree | moderately disagree | weakly disagree | weakly agree | moderately agree | strongly agree

**9 If I see my reflection in a shop window, I will examine my movements.**

strongly disagree | moderately disagree | weakly disagree | weakly agree | moderately agree | strongly agree

**10 I am concerned about what people think about me when I am moving.**

strongly disagree | moderately disagree | weakly disagree | weakly agree | moderately agree | strongly agree

## Appendix B

## Day-to-Day Experiences

**Instructions: Below is a collection of statements about your everyday experience. Using the 1-6 scale below, please indicate how frequently or infrequently you currently have each experience. Please answer according to what *really reflects* your experience rather than what you think your experience should be. Please treat each item separately from every other item.**

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| Almost Always | Very Frequently | Somewhat Frequently | Somewhat Infrequently | Very Infrequently | Almost Never |

| | | | | | | |
|---|---|---|---|---|---|---|
| I could be experiencing some emotion and not be conscious of it until some time later. | 1 | 2 | 3 | 4 | 5 | 6 |
| I break or spill things because of carelessness, not paying attention, or thinking of something else. | 1 | 2 | 3 | 4 | 5 | 6 |
| I find it difficult to stay focused on what's happening in the present. | 1 | 2 | 3 | 4 | 5 | 6 |
| I tend to walk quickly to get where I'm going without paying attention to what I experience along the way. | 1 | 2 | 3 | 4 | 5 | 6 |
| I tend not to notice feelings of physical tension or discomfort until they really grab my attention. | 1 | 2 | 3 | 4 | 5 | 6 |
| I forget a person's name almost as soon as I've been told it for the first time. | 1 | 2 | 3 | 4 | 5 | 6 |
| It seems I am "running on automatic," without much awareness of what I'm doing. | 1 | 2 | 3 | 4 | 5 | 6 |
| I rush through activities without being really attentive to them. | 1 | 2 | 3 | 4 | 5 | 6 |
| I get so focused on the goal I want to achieve that I lose touch with what I'm doing right now to get there. | 1 | 2 | 3 | 4 | 5 | 6 |
| I do jobs or tasks automatically, without being aware of what I'm doing. | 1 | 2 | 3 | 4 | 5 | 6 |
| I find myself listening to someone with one ear, doing something else at the same time. | 1 | 2 | 3 | 4 | 5 | 6 |
| I drive places on 'automatic pilot' and then wonder why I went there. | 1 | 2 | 3 | 4 | 5 | 6 |
| I find myself preoccupied with the future or the past. | 1 | 2 | 3 | 4 | 5 | 6 |
| I find myself doing things without paying attention. | 1 | 2 | 3 | 4 | 5 | 6 |
| I snack without being aware that I'm eating. | 1 | 2 | 3 | 4 | 5 | 6 |

## Appendix C

**Focus Instructions**

| | **Internal focus instructions** | **External focus instructions** |
|---|---|---|
| **Conscious monitoring group** | Each time you throw, visually focus on the target, and mentally focus on the motion of your arm and be aware of how it moves. | Each time you throw, visually focus on the target, and mentally focus on the motion of the dart and be aware of how it flies. |
| **Conscious control group** | Each time you throw, visually focus on the target, and mentally focus on the motion of your arm and think about how it should move. | Each time you throw, visually focus on the target, and mentally focus on the motion of the dart and think about how it should fly. |

**Visual rating scales after the 2nd and 3rd blocks**

On the line below, please indicate how well you were able to adopt / sustain the instructed focus


On the line below, please indicate whether the instructed focus disturbed your performance

**Visual rating scales after the 4th block**

On the line below, please indicate whether during the **first** block your focus was more similar to the internal or to the external focus


On the line below, please indicate whether during the **last** block your focus was more similar to the internal or to the external focus