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Bram Van den Bergh, Julien Schmitt, Siegfried Dewitte and Luk Warlop

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Bending Arms, Bending Discounting Functions. How Motor Actions Affect Intertemporal Decision-Making.

BRAM VAN DEN BERGH

JULIEN SCHMITT

SIEGFRIED DEWITTE

LUK WARLOP*

*Bram Van den Bergh (bbergh@rsm.nl) is Assistant Professor at the Erasmus University, Rotterdam School of Management (Marketing Management), P.O. Box 1738, 3000 DR Rotterdam, the Netherlands. Julien Schmitt (J.Schmitt@lboro.ac.uk) is Lecturer at Loughborough University Business School (Marketing), Leicestershire, LE11 3TU, Loughborough, United-Kingdom. Siegfried Dewitte (Siegfried.Dewitte@econ.kuleuven.be) is Associate Professor at the KULeuven, Faculty of Business and Economics (Marketing), Naamsestraat 69, B-3000 Leuven, Belgium. Luk Warlop (Luk.Warlop@econ.kuleuven.be) is Professor at the KULeuven, Faculty of Business and Economics (Marketing), Naamsestraat 69, B-3000 Leuven, Belgium and at the Norwegian School of Management (BI), Nydalsveien 37, N-0484, Oslo, Norway. The authors gratefully acknowledge the financial support from the Research Foundation Flanders (FWO) and the KULeuven.

In five studies we demonstrate that task-irrelevant somatic activity influences intertemporal decision making: Arm movements associated with approach (arm flexion), rather than avoidance (arm extension), instigate present-biased preferences. We show that the preference for immediate over delayed gratification is moderated by the sensitivity of the approach system and, owing to learning principles, restricted to arm positions of the dominant hand. This research extends the effects of somatic activity beyond attitude formation and cognition, and provides empirical evidence for the effect of somatic activity on motivational systems.

INTRODUCTION

Many consumer decisions involve trading off costs and benefits over time (Laibson 1997; Lynch and Zauberman 2006; Malkoc and Zauberman 2006; Soman et al. 2005). For example, a consumer may think about replacing a two-year-old car with a shiny new model, rather than driving his old car and saving for retirement. When considering delivery options for purchases, consumers need to decide between a fast, more expensive delivery and a lengthier, cheaper one. Similarly, a dieter may find that a fattening chocolate cake is irresistible in the short run, although a fruit salad is more beneficial in the long run. In making such decisions, consumers trade off long run and short run benefits. Our research examines the effect of bodily feedback from motor actions on such intertemporal tradeoffs. We test whether basic motor actions, such as extending or flexing one's arm, affect intertemporal decision-making. More specifically, we conjecture that somatic motor actions associated with "approach" lead to present-biased preferences. We demonstrate arm flexor contraction makes individuals more likely to choose immediately pleasing options. That is, flexing your elbow may cause you to spend now rather than to save for later or may lead you to prefer chocolate cake over fruit for dessert. We demonstrate that this effect is regulated by the Behavioral Approach System (Gray 1987, 1990) by showing that the effect of arm flexor contraction is moderated by the sensitivity of the brain circuitry processing rewards: Only when the Behavioral Approach System is sensitive enough to be activated by somatic actions, impatience is observed. Furthermore, we suggest that the effect of arm flexion on present-biased preferences relies on the learned association between arm flexor contraction and the activation of the Behavioral Approach system by showing that the effect of arm flexor contraction is moderated by hand dominance. In the absence of a learning process, the association between arm flexion and approach is most likely not established. We show that present-biased preferences following arm flexor contraction is observed only for the dominant hand.

In the following, we discuss prior research on the effects of task-irrelevant somatic activity, develop three hypotheses and present one correlational field study and four experimental lab studies demonstrating that motor actions influence intertemporal decision making.

CONCEPTUAL FRAMEWORK

Bodily positions influence cognitions and attitudes (Cacioppo, Priester, and Berntson 1993; Centerbar and Clore 2006; Friedman and Förster 2002; Kawakami et al. 2007; Neumann and Strack 2000; Priester, Cacioppo, and Petty 1996). For example, the evaluation of consumer goods is influenced by nodding or shaking your head (Förster 2004) and holding a pen between your teeth makes you evaluate cartoons differently (Strack, Martin, and Stepper 1988). Task-irrelevant somatic activity associated with approach or withdrawal reflexes can bias preference judgments toward otherwise neutral stimuli. Simply by pairing stimuli with arm flexion (where the motor action is directed toward the self) or arm extension (where the motor action is directed away from the self), rudimentary attitudes can be established. Indeed, Chinese ideographs presented during arm flexion are ranked more positively than ideographs presented during arm extension (Cacioppo et al. 1993). Follow-up studies have corroborated and extended these results (Centerbar and Clore 2006; Förster 2004; Priester et al. 1996). The enactment of approach and avoidance behaviors can influence attitudes in a predictable fashion, with people generally evaluating objects more (less) favorably after approach (avoidance) actions (Kawakami et al. 2007).

The effects of motor actions are not restricted to developing attitudes: Somatic actions, such as arm flexion and extension, exert an influence on cognitive processing as well (Barsalou 2008). For example, arm flexion, relative to arm extension, facilitates the solution of tasks containing aspects of insight problem solving and creative generation (Friedman and Förster 2000, 2002), broadens the scope of conceptual attention (Förster et al. 2006), enhances the flexibility of attention (Friedman and Förster 2005), makes conjunction errors less likely to appear (Riis and Schwarz 2003), facilitates the categorization of positive words (Neumann and Strack 2000) and facilitates the retrieval of positively valenced information from long-term memory (Förster and Strack 1997, 1998).

Although people associate flexion and extension with the words *approach* and *withdraw*, and not with *pleasant* or *unpleasant* (Cacioppo et al. 1993), the bulk of prior research has documented effects of arm positions on attitude formation and far less so on motivational processes. We propose that arm flexion and extension engage motivational systems and we conjecture that the effects of arm positions extend beyond attitude formation and cognition. Evidence that speaks to this comes from studies demonstrating that the intensity of pressure exerted through arm flexion and extension functions as an indicator of motivational strength (Förster, Higgins, and Idson 1998). Also, arm positions are able to influence consumption and thus, appetitive motivation: Förster (2003) demonstrated that individuals flexing their arm consume more chocolate cookies and orange juice than individuals who extend their arm. Notably, the consumption of lukewarm water is unaffected by arm positions. These findings suggest that the motivational or appetitive effects of arm flexion are confined to inherently gratifying or rewarding objects that provide immediate benefits. In this research, we hypothesize that arm flexion activates the motivational system concerned with the processing of rewards (such as chocolate cookies and orange juice, but not lukewarm water). Because activation of the motivational approach system leads individuals to prefer temporally proximal outcomes above those being temporally distant (Van den Bergh, Dewitte, and Warlop 2008), we hypothesize that arm flexion instigates present-biased preferences.

HYPOTHESES DEVELOPMENT

In general, people prefer rewards sooner than later. That is, $1000 received today is typically worth more than $1000 received next year, because delaying a reward reduces the subjective value of that reward (Frederick, Loewenstein, and O'Donoghue 2002; Green and Myerson 2004; Soman et al. 2005). To compensate the delay, individuals want the delayed reward to be larger than the sooner reward. Intertemporal choices and decisions are by no means constant nor fixed: Our preferences are dynamically inconsistent. For example, some people prefer 1 apple right now over 2 apples tomorrow, but virtually nobody prefers 1 apple in 30 days over 2 apples in 31 days (Thaler 1981), although the temporal interval between the rewards is identical. One of the reasons why our preferences are dynamically inconsistent is that temporal proximity to rewards instigates impatience: An identical positive outcome will become increasingly attractive the closer it is located in time to the time of decision-making (Green and Myerson 2004).

Because bodily states may influence time perception (Chambon, Droit-Volet, and Niedenthal 2008; Effron et al. 2006), motor actions may affect intertemporal decision making.

Based on the principle of compatibility (Strack and Deutsch 2004), already being engaged in a type of approach or avoidance behavior might facilitate other motivationally compatible behaviors (Strack, Werth, and Deutsch 2006). Since orientation toward approach facilitates a decrease in the distance between the person and an aspect of the environment, arm flexion may induce a sense of proximity, fostering impatience as a consequence. Indeed, temporal (Frederick et al. 2002; Green and Myerson 2004) and physical (Loewenstein 1996; Mischel and Ebbesen 1970) proximity to rewards initiate impulsiveness. In sum, we predict that arm flexion, rather than arm extension, leads to an increased preference for smaller, immediate rewards over larger, but delayed rewards.

H1: Arm flexion, rather than arm extension, leads to present-biased preferences.

Research inquiries in different domains have independently identified two distinct motivational systems (e.g., Gray 1987, 1990; Higgins 1997, 1998) one concerned with avoiding negative outcomes (“avoid pain”), the other with obtaining positive outcomes (“approach pleasure”). These two systems have been described in different domains of inquiry with varying terminology, depending on the research programs in which they have emerged (Carver, Sutton, and Scheier 2000; Gable, Reis, and Elliot 2003). In Gray’s (1987, 1990) Reinforcement Sensitivity Theory, the Behavioral Inhibition System (BIS) is concerned with avoiding punishments, while the Behavioral Approach System (BAS) is the conceptual substrate concerned with approaching rewards. The purpose of the BAS is to initiate approach behavior that brings the organism closer to reinforcers.

In this research, we propose that arm flexion engages the BAS in a similar way as exposure to lingerie (Van den Bergh et al. 2008) or sampling a delicious drink (Wadhwa, Shiv, and Nowlis 2008). Activation of the BAS leads to a greater preference for smaller, immediate rewards over larger, delayed rewards (Van den Bergh et al. 2008) and to an increased preference for hedonic items (Wadhwa et al. 2008). Because impulsivity is characterized by generalized reward sensitivity (Ramanathan and Menon 2006) and because the sensitivity of motivational systems can vary substantially from one individual to the next (Carver and White 1994; Torrubia et al. 2001), we hypothesize that the effect of self-directed flexor movements (i.e., approach actions) on present-biased preferences is moderated by the sensitivity of the Behavioral Approach System. That is, the effect of induced approach (i.e., arm flexion) should be dependent on approach system sensitivity (i.e., BAS). To our knowledge, no other study has ever investigated the role of motivational systems, like the BAS, in the effects of arm positions, despite the putative link between arm positions and motivational tendencies.

H2: The effect of arm flexion, rather than arm extension, on present-biased preferences is dependent on the sensitivity of the Behavioral Approach System (BAS).

In contacting an aversive stimulus, extending the arm is temporally associated with the onset of the aversive stimulus, whereas flexing the arm is coupled with its offset. On the other hand, in retrieving something desirable, arm flexion is more closely temporally associated to the acquisition of the desired object than arm extension. A lifetime of experience of motor actions paired with differential evaluative outcomes can establish higher-order associations. The countless repetitions over an individual's lifetime of the pairing of somatic actions (such as arm flexion) with evaluative contingencies (such as acquiring or consuming a desired object) foster an association between arm flexion and approach motivational orientations (Cacioppo et al. 1993). Without these countless repetitions (i.e., in the absence of a learning process) the association between flexion and approach orientation is most likely not established. Evidence that provides support for this contention comes from the finding that Chinese ideographs presented during “leg flexion” are not rated differently than ideographs presented during “leg extension” (Cacioppo et al. 1993). That is, attitudinal effects were not obtained when subjects sat on the edge of a desk and pressed their heels against that desk (i.e., leg flexion) or their toes against a second desk (i.e., leg extension). Presumably, leg positions have not been paired with differential evaluative outcomes and have not fostered higher-order associations.

Further evidence providing support for a learning account of associating motor patterns with attitudes, is found in studies comparing experts and novices. For example, skilled typists prefer letter dyads that, if typed, do not create motoric interference, while novice typists do not show this preference (Beilock and Holt 2007; Van den Bergh, Vrana, and Eelen 1990). The effects of extending one’s middle finger or thumb (Chandler and Schwarz 2009) and the effects of head-nodding or shaking (Förster 2004) also point to the influence of learned movements, as opposed to innate motor movements, upon affect and cognition. Since individuals use their nondominant hand less often than their dominant hand, the association between arm flexion of the nondominant hand and approach orientation is most likely only weakly established. Thus, we hypothesize that the effect of arm flexion on the preference for immediate gratification will be stronger for arm positions of the dominant hand. To our knowledge, no other study has ever investigated the role of conditioning in the effects of arm positions. Although most scholars assume that a lifetime of experience of motor actions paired with differential evaluative outcomes has established higher-order associations, we are unaware of research explicitly testing the role of a learning process in establishing the association between flexion and approach orientation.

H3: The effect of arm flexion, rather than arm extension, on present-biased preferences via Behavioral Approach System activation is stronger for the dominant arm than the nondominant arm.

OVERVIEW OF STUDIES

We conducted one correlational field study and four experimental lab studies. In the pilot study, we test whether consumers using a shopping basket (i.e., arm flexion) are more likely to purchase products providing immediate benefits than consumers using a shopping cart (i.e., arm extension). Because of the correlational nature of this field study, we designed 4 follow-up experiments to demonstrate the causal path that leads from arm flexion to present-biased preferences. Study 1A and 1B test whether hypothesis 1 holds; that is, they are designed to test whether arm flexion–rather than arm extension–leads to present-biased preferences. In study 2 we test whether this effect is moderated by the sensitivity of the BAS (i.e., hypothesis 2); that is, we test whether the preference for immediate gratification resulting from arm flexion is dependent on the sensitivity of the motivational approach system. Study 3 aims to provide further support for the second hypothesis and aims to test hypothesis 3, namely that the effect of arm flexion on preference for immediate gratification is restricted to approach system activation by means of the dominant arm. We employ somewhat different procedures across studies to assess present-biased preferences. We use purchasing behavior (pilot study), a choice task (study 1A and 1B), a matching task (study 2) and a titration procedure (study 3) to generalize our findings across procedures. In combination, these five studies demonstrate that basic motor actions influence intertemporal decision-making through activation of the motivational approach system.

In all experimental studies we used a screening procedure to probe attention and motivation. Participants had to answer questions that identified possible random response behavior: They were instructed not to respond to a scale but to click a dot next to the question (Oppenheimer, Meyvis, and Davidenko 2009). Data from participants not following this instruction [study 1b: $n = 2$ (i.e., 4%); study 2: $n = 3$ (i.e., 3%); study 3: $n = 7$ (i.e., 6%)] were discarded, because their responses on focal variables cannot be trusted.

PILOT STUDY

To test the hypothesis that arm flexion instigates present-biased preferences (hypothesis 1), we investigate whether customers carrying a shopping basket (i.e., arm flexion) have a greater preference for products providing immediate benefits than consumers pushing a shopping cart (i.e., arm extension). The preference ordering of ‘vice’ and ‘virtue’ goods changes with whether consumers evaluate immediate or delayed consumption consequences (Wertenbroch 1998). A vice option is able to provide relatively more immediate benefits than a virtue, while a virtue provides more delayed benefits than a vice (Li 2008). For example, ignoring long-term health effects, some consumers prefer chocolate cake (relative vice) over a bowl of fruit salad (relative virtue), because they prefer the taste of the former. However, ignoring these short-term taste differences, other consumers prefer fruit over cake, because they consider the long-term health consequences of eating high caloric snacks or healthy food. In this non-experimental, correlational field study, we test whether customers using a shopping basket are more likely to purchase vice products than customers using a shopping cart.

Method

We tracked 136 customers in a hypermarket from their entry in the store until their exit. Shoppers were selected on a random basis to minimize sampling bias and received no incentive for participation. We inconspicuously tracked the customer's path in the store with a personal digital assistant (store areas visited), the time spent in the store and the shopping support used (cart or basket). Based on the customer's purchase ticket collected at the end of the shopping trip, we obtained information about the products bought, the number of products bought and the total amount of money spent in the store. Table 1 lists the most important differences in shopping trip characteristics between the different categories of shoppers (cart and basket shoppers). These differences may contribute to impulsive spending: For example, increasing the amount of time spent in the store leads to an increase in unplanned purchasing (e.g., Inman, Winer, and Ferraro 2009). Hence, we will control for these differences in the statistical analyses.

We hypothesized that prolonged activation of the arm flexion muscles instigates a preference for products offering immediate benefits. That is, we hypothesized that 'basket shoppers' would be more likely to purchase vice products than 'cart shoppers'. Because the different categories of shoppers visit different areas in the store and do so for a varied period of time, we compare purchase behavior of basket shoppers and cart shoppers at the cash register, as this is the only location in the store that all shoppers need to pass. We predict that basket shoppers are more likely to purchase vice products (i.e., chocolate bars, candy boxes, etc.) than cart shoppers at the shelves located at the cash register.

Insert table 1 about here

Results

As suggested by table 1, basket shoppers are more likely to buy vice products at the cash register than cart shoppers ($F(1, 134) = 18.998$ $p < .001$). Even when adding all covariates (Number of products bought, Amount spent and Store visit duration) simultaneously to the general linear model, Shopping Support predicts whether consumers purchase vice products at the cash register ($F(1,131) = 13.919$, $p < .001$).

To control for differences between cart shoppers and basket shoppers with respect to the shopping trip characteristics (see table 1), we selected a matched subsample of cart shoppers that was not statistically different from the basket shoppers on any of these characteristics (Number of products purchased, Amount spent, Store visit duration). Using a step-by-step procedure, we selected the characteristic with the greatest difference between the two samples (largest p-value) and removed the cart shopper that differed most from the average basket shopper on that characteristic (greatest absolute difference). This procedure was repeated until we obtained a matched subsample of cart shoppers (n=33) that was statistically not different from the basket shopper sample (i.e., average number of products purchased = 12.1; average amount spent =

€33,2; average store visit duration = 18 min). In subsequent analyses, we compare the basket shoppers with this matched subsample of cart shoppers.

An ordered logistic regression (see specification [1] in table 2) demonstrates that Shopping Support (0 = cart; 1 = basket) predicts the likelihood of buying a vice product (0= not buying vice product; 1= buying vice product). Subsequent specifications control for differences in shopping visit characteristics: Specifications [2], [3] and [4] suggest that the effect of Shopping Support remains significant when controlling respectively for Store visit duration, Amount spent, and Number of products bought. Specification [5], containing all three covariates, demonstrates that Shopping Support still predicts whether customers purchase vice products at the cash register. In all five specifications, basket shoppers are more likely to purchase vice products than the matched subsample of cart shoppers. The ratio-changes reported in table 2 represent the change in the odds of purchasing a vice product for a one-unit change in the predictor variable (e.g., a change from cart to basket). Specification [5] suggests that the odds of purchasing vice products at the cashier for a basket shopper is 21.74 times the odds of purchasing vices for a cart shopper, all other things being equal.

Insert table 2 about here

Discussion

This non-experimental field study suggests that arm flexion instigates present-biased preferences. Consistent with the speculative hypothesis put forward by Förster (2004), customers carrying a shopping basket (i.e., arm flexion) are more likely to purchase products offering immediate benefits than customers pushing a shopping cart (i.e., arm extension). Although we statistically controlled for several potential confounding variables that might explain the difference between cart and basket shoppers, customers shopping with a basket consistently displayed significantly greater present-biased preferences than customers using a cart. Despite our efforts to statistically control for possible confounds, this study suffers from the limitations that many, if not all, non-experimental field studies suffer from (e.g., self-selection, unobserved differences, etc.). Because of the correlational nature of this pilot study, we designed 4 follow-up experiments to demonstrate the causal path that leads from arm flexion to present-biased preferences.

STUDY 1A & 1B

In the first two experimental lab studies, our aim is to test the hypothesis that arm flexion, rather than arm extension, leads to present-biased preferences. Because study 1A & 1B are conceptually identical in design, we discuss them together. As in the pilot study, we operationalized present-biased preferences as a preference for vices over virtues in study 1A. In study 1B, we test hypothesis 1 more directly: We hypothesize that individuals flexing their arm prefer smaller, sooner over larger, later monetary rewards, than individuals extending their arm. In sum, we test whether somatic activity associated with approach leads to present-biased preferences (i.e., a greater preference for vices over virtues [study 1a]; a greater preference for smaller, sooner over larger, later rewards [study 1b]).

Participants and method

On arrival, participants (study 1A: $n = 22$; 12 women; study 1B: $n = 54$; 26 women, participation for course credit) were seated in partially enclosed cubicles, which prevented them from having contact with each other. Ostensibly to investigate the effect of brain hemispheric lateralization (Friedman and Förster 2000), participants were asked to press one of their hands against the table. To activate either the approach or avoidance system, we used the procedure developed by Cacioppo et al. (1993): Participants in the arm flexion condition were asked to put the palm of one of their hands under the table and press upward, whereas participants in the arm extension condition were asked to put the palm of one of their hands on the table and press downward. In both conditions, participants were asked to maintain a slight pressure against the table during the entire task and to work through the computerized task using their one free hand.

While participants maintained a slight pressure against the table, they were offered five (study 1A) / eight (study 1B) choices (Li 2008). In study 1A, participants chose between objects that were categorized as either a vice or a virtue (e.g., camping versus studying over the weekend). In study 1B participants were offered choices between a smaller-sooner and a larger-later monetary reward (e.g., €67 tomorrow vs. €85 in 70 days). Participants had to indicate on a 100-point visual analogue scale whether they preferred 'option A' (= 0) or 'option B' (= 100) with 'indifferent' as midpoint (= 50). The responses were recoded and averaged such that a higher score indicated a greater preference for vice options (study 1A) or for smaller, sooner monetary rewards (study 1B). Participants discontinued the arm position after indicating their preferences.

Results and discussion

In study 1A, participants showed a greater preference for vice options relative to virtues, $t(20) = 2.57$, $p < .05$, in the arm flexion condition ($M = 59$) than in the arm extension condition ($M = 43$). In study 1B, they had a greater preference for smaller, earlier rewards, $t(52) = 2.43$, $p < .05$, in the arm flexion condition ($M = 53$) than in the arm extension condition ($M = 39$). These two experiments demonstrate that somatic activity associated with approach leads to a preference for immediate over delayed benefits (i.e., present-biased preferences).

STUDY 2

In study 2, we investigate whether delaying a monetary reward leads to a steeper reduction in the subjective value of that reward when people flex their arm. Furthermore, our aim is to provide support for hypothesis 2 by demonstrating that the effect of arm flexor contraction on delay discounting is dependent on the sensitivity of the Behavioral Approach System (Gray 1987, 1990): Only when the approach system is sensitive enough to be activated by arm flexor contraction, a preference for smaller, immediate rewards should be observed. In sum, we predict that the effect of arm flexion on temporal discounting of money is moderated by the sensitivity of the BAS.

Participants and method

The same laboratory setting and cover story as in the previous experimental studies were used: Participants ($n = 105$; mean age = 21; 59 women; participation in return for a participation fee [€6]) were asked to press one of their hands against the table and maintain a slight pressure against the table, while they equated two intertemporal options (e.g., €15 now = € ____ in one week). Participants specified the amount of money they would require in one week, one month, three months, six months and one year to make them indifferent to receiving €15 now (Van den Bergh et al. 2008). This matching task allows us to specify a discounting function for each participant over a time interval of one year. Following Myerson, Green, and Warusawitharana (2001), we consider the area under the empirical discounting function as a measure of temporal discounting. A smaller area under the curve indicates a greater preference for earlier rewards (i.e., present-biased preference) and this measure can vary between 0.0 (steepest possible discounting) and 1.0 (no discounting), (see Myerson et al. (2001) for details regarding the calculation of the area under the curve). This nonparametric measure provides a single and easy statistic that can be used to compare groups and does not depend on any theoretical assumptions regarding the form of the discounting function (Myerson et al. 2001).

Afterwards, respondents discontinued the arm position and were asked how pleasant and how physically strenuous it was to press their hand against the table (1 = *not at all*, 7 = *very much*) and had to indicate how they felt right now (1 = *very bad*, 9 = *very good*). Subsequently, they answered the Sensitivity to Punishment Sensitivity to Reward Questionnaire (SPSRQ) (Torrubia et al. 2001), a scale developed to assess Gray's behavioral approach and inhibition constructs, which consists of 48 yes/no items such as “Do you often do things to be praised?” (SR) and “Are you often afraid of new or unexpected situations?” (SP). The 24 Sensitivity to Reward (SR) items were summed to obtain a SR score (Cronbach’s alpha = .74). Including the Sensitivity to Punishment scale in statistical analyses didn’t produce any significant effects and is ignored in the remainder.

Results

Six outliers were removed. An observation is declared an outlier if it lies outside of the interval [Q1-1.5×IQR; Q3+1.5×IQR], where IQR=Q3-Q1 is called the Interquartile Range (Tukey 1977). We use this definition across the studies. A general linear model (GLM) analysis was used for the analysis. Muscle Contraction (flexion = 1, extension = -1) was entered as a discrete between subjects factor, whereas Sensitivity to Reward (SR) was mean centered and entered as a continuous between subjects factor. This GLM revealed no effect of Muscle Contraction on temporal discounting of money, $F(1, 95) = .96$, $p = .33$, a marginally significant main effect of SR, $F(1, 95) = 2.94$, $p = .09$, and a significant interaction between Muscle Contraction and SR, $F(1, 95) = 4.50$, $p < .05$. Figure 1 shows the plot of this interaction.

Insert figure 1 about here

Analyses of simple slopes (Aiken and West 1991) indicated that participants with a highly sensitive BAS (1 *SD* above the mean) discount monetary rewards more steeply in the flexion than in the extension condition ($\beta = -.063$, $t(95) = -2.19$, $p < .05$). This effect was not obtained ($\beta = .024$, $t(95) = .817$, $p = .42$) among those with a rather insensitive BAS (1 *SD* below the mean). BAS sensitivity did predict discounting in the flexion condition ($\beta = -.02$, $t(51) = -2.90$, $p < .01$), but did not predict delay discounting in the extension condition ($\beta = .002$, $t(44) = .27$, $p = .79$), indicating that the effect of arm flexion on delay discounting of monetary rewards is dependent on the sensitivity of the BAS. Greater sensitivity for reward is associated with a preference for smaller, earlier rewards, but only while flexing the arm.

No significant differences in mood, strenuousness or pleasantness of the arm position were obtained between conditions and adjusting for these variables as covariates in the reported analyses did not change the pattern of results reported above, suggesting that these variables do not mediate the effect of arm flexion on delay discounting.

Discussion

This study demonstrates that delaying a monetary reward leads to a steeper reduction in the subjective value of that reward when people flex their arm. That is, arm flexion leads to a greater valuation of immediate rewards than arm extension. Furthermore, this study shows that the effect of arm flexor contraction on impatience for monetary rewards is dependent on the sensitivity of the BAS: Only when the motivational system is sensitive enough to be activated by arm flexor contraction, a heightened preference for immediately available rewards was observed. That is, the effect of arm flexion on the preference for immediate gratification is restricted to individuals with a highly sensitive BAS.

STUDY 3

In this final study, our goal is twofold: First, we aim to replicate study 2 by showing that the effect of arm flexion is dependent on the sensitivity of the motivational approach system. Second, we attempt to test hypothesis 3 by investigating whether the effect of arm flexion is restricted to arm positions of the dominant hand. Since individuals more often use their dominant hand to acquire or consume a desired object, the association between arm flexion and approach orientation is probably stronger for positions of the dominant hand than the nondominant hand. We predict that the effect of arm flexion of the dominant arm (hypothesis 3) on the preference for immediate gratification is restricted to individuals possessing a sensitive approach system (hypothesis 2). In all previous studies, we used the arm extension condition as a control group. In this final study, we include an additional control condition, in which participants did not have to maintain an arm position.

Participants and method

Participants were 120 students (69 women, mean age = 20). Two students participated in return for a participation fee (€6) and 118 students participated in return for course credit. The same laboratory setting and cover story as in the previous studies were used. In addition to a control condition, in which participants did not have to maintain an arm position, participants in the experimental conditions were asked to press their dominant or nondominant hand against the table (manipulated between subjects). Participants in the arm flexion condition were asked to put the palm of their (non) dominant hand under the table and press upward, whereas participants in the arm extension condition were asked to put the palm of their (non) dominant hand on the table and press downward. In the four experimental conditions (dominant/nondominant hand × flexion/extension), participants were asked to maintain a slight pressure against the table during the temporal discounting task. In the control condition, participants did not have to maintain an arm position and could work through the computerized task using both free hands.

Participants chose between a smaller-sooner (SS) and a larger-later (LL) amount (e.g., Which would you prefer: €15 today or €30 one week from today?). The SS amount was fixed and participants adjusted the LL amount through successive choices. They were instructed to bring the SS and LL amounts toward an indifference point (where the two amounts have the same present value). Following a ‘splitting the difference’ procedure (Read 2001), LL was adjusted upwards if SS was preferred, while LL was adjusted downwards if LL was chosen. The indifference point was defined as the midpoint between the highest value judged as too low (called *highup*), and the lowest value judged as too high (called *lowdown*). A choice sequence was ended when the magnitude of the relative difference between highup and lowdown was smaller than 1% (i.e., an indifference point was reached). Indifference values (i.e., the value of the variable amount at the indifference point) were collected for time intervals of one week, one month, three months, six months and one year. The value of the SS amount was fixed at €15 and the starting value of the variable LL amount (i.e., €30) was kept constant across the different time intervals. This titration procedure allowed us to specify a discounting function for each participant over a time interval of one year. As in study 2, we consider the area under the empirical temporal discounting function as a measure of temporal discounting (Myerson et al. 2001). Although there is no theoretical basis for preferring this titration procedure over a choice task (study 1A and 1B) or a matching task (study 2) (Frederick et al. 2002), the different methods to assess temporal discounting may yield different outcomes (Frederick et al. 2002). To generalize our findings across procedures, we preferred a titration procedure to assess present-biased preferences.

Afterwards, respondents discontinued the arm position and were asked how pleasant and how physically strenuous it was to press their hand against the table (1 = *not at all*, 7 = *very* *much*) and had to indicate how they felt right now (1 = *very bad*, 9 = *very good*). Subsequently, they answered the Sensitivity to Reward Questionnaire (Torrubia et al. 2001), to assess the sensitivity of the Behavioral Approach System. A general Sensitivity to Reward (SR) index was created in a similar fashion as in study 2 (Cronbach's alpha = .77). Including the Sensitivity to Punishment scale in statistical analyses didn't produce any significant effects and is ignored in the remainder.

Results

Three outliers were removed. The temporal discounting measure was subjected to a GLM analysis with Muscle Contraction (flexion = 1, extension = -1), Hand (dominant = 1, nondominant = -1), and Sensitivity to Reward (mean centered and entered as a continuous factor), and all interactions as independent variables. The GLM analysis revealed a significant effect of Hand, $F(1, 62) = 4.37$, $p < .05$, and a marginally significant three-way interaction between Muscle Contraction, Hand and SR scores, $F(1, 62) = 3.78$, $p < .06$. To explore this interaction effect, two separate GLMs were conducted within the dominant and nondominant hand conditions. Within the dominant hand condition, a GLM with Muscle Contraction, SR scores and the interaction between the two variables, revealed no effect of Muscle Contraction, $F(1, 31) = .09$, $p = .76$, no effect of SR scores, $F(1, 31) = 2.52$, $p = .12$, but a significant interaction between Muscle Contraction and SR scores, $F(1, 31) = 8.13$, $p < .01$. Figure 2a shows the plot of this interaction. Analyses of simple slopes indicated that participants with a highly sensitive BAS (1 *SD* above the mean) discount monetary rewards more steeply in the flexion than in the extension condition ($\beta = -.101$, $t(31) = -2.592$, $p < .05$). Among those with a rather insensitive BAS (1 *SD* below the mean), there was a trend in the opposite direction (β = .077, t(31) = 1.699, *p* = .099). BAS sensitivity did predict discounting in the flexion condition (β = -.03, t(13) = -2.74, *p* < .05) but did not predict delay discounting in the extension condition (β = .009, t(18) = 1.14, *p* = .26), indicating that greater sensitivity for reward is associated with a preference for smaller, earlier rewards, but only while flexing the dominant arm. Similar analyses within the nondominant hand condition, revealed no main effects, nor an interaction effect (all *F*s < 1): The association between SR scores and temporal discounting was nonsignificant in both the extension (β = -.006, t(17) = -.47, *p* = .64) and the flexion (β = -.0007, t(14) = -.06, *p* = .95) condition, see figure 2b. The control condition (no Muscle Contraction, and thus also no Hand manipulation) was analyzed independently: A subsidiary analysis within the control condition revealed no significant association between SR scores and temporal discounting either, β = -.0017, t(46) = -.21, *p* = .84, see figure 2c.

Insert figure 2 a,b,c about here

No significant differences in the strenuousness and pleasantness of the arm position were obtained between conditions and adjusting for these variables as covariates in the reported analyses did not change the pattern of results. Although participants in the extension condition (*M* = 5.64) reported feeling significantly worse than those in the flexion condition (*M* = 6.32), *t*(115) = 2.04, *p* < .05 and marginally worse than those in the control condition (*M* = 6.17), *t*(115) = 2.04, *p* = .07, including mood as a covariate in the analyses did not change the pattern of the results above, suggesting that mood does not mediate the effect of arm flexion on delay discounting.

Discussion

This final experiment demonstrates that the effect of arm flexion on present-biased preferences is moderated by the sensitivity of the Behavioral Approach System, and probably owing to principles of conditioning, is restricted to arm flexion of the dominant arm. We suggest that actions of the nondominant arm have not fostered higher-order associations between motor actions and evaluative outcomes, and are not able to activate the BAS. In sum, the effect of arm flexion on preference for immediate gratification is restricted to BAS activation by means of the dominant arm

GENERAL DISCUSSION

Five studies demonstrate that task-irrelevant somatic activity is able to influence intertemporal decision making: Simply flexing one's arm leads to present-biased preferences. That is, arm movements associated with approach lead to a preference for vices over virtues and for smaller, earlier rewards over larger but later rewards. Despite the putative link between arm positions and motivational tendencies, the bulk of previous research investigating the effects of arm positions have focused on attitude formation and cognition. Our studies demonstrate effects of somatic actions beyond attitude formation and cognitive processing and indicate that biofeedback resulting from muscle contraction may influence intertemporal decision making through activation of motivational systems.

Our findings suggest that cues that activate the Behavioral Approach System may instigate present-biased preferences. Prior research has already demonstrated that sampling a highly rewarding drink or food (Wadhwa et al. 2008) or touching lingerie (Van den Bergh et al. 2008) may activate motivational tendencies (i.e., the BAS) that lead to present-biased preferences. We have demonstrated that the effect of arm flexor contraction is dependent on the sensitivity of the BAS. To our knowledge, we are the first to show the role of the sensitivity of motivational systems in the effects of arm movements. Although Cacioppo et al. (1993, experiment 4) provided evidence that arm flexion and extension activate different motivational orientations, the results were based on subjects' associations between concepts. The intensity of pressure exerted through arm flexion and extension has been used an indicator of motivational strength (Förster et al. 1998), but very few studies have investigated whether arm flexion and extension have motivational consequences (for a notable exception see Förster 2003). Since the effect of arm flexion is dependent on the sensitivity of our motivational approach system, we are able to confirm the putative link between arm movements and motivational orientations.

Notably, our results provide an explanation for why arm flexion does not affect the consumption of lukewarm water (Förster 2003): If the motivational approach system regulating our responses towards rewards (i.e., the BAS) is causing the increase in craving/appetite, it is not surprising to observe effects of arm flexion on the consumption of '*delicious chocolate cookies filled with sweet orange marmalade*' and '*delicious orange juice from a luxurious brand*', and no effects for neutral lukewarm water. Since the BAS only regulates responses to rewarding items, it is not surprising that BAS activation through arm flexion does not affect consumption of neutral 'objects' like lukewarm mineral water (Förster 2003). Presumably, effects for lukewarm water may be obtained if the rewarding properties of lukewarm water are increased (e.g., when individuals are thirsty or when they have eaten salty pretzels).

To our knowledge, no other study has investigated the role of conditioning as the causal mechanism fostering higher order associations between motor actions of the arm and evaluative outcomes. According to Cacioppo and colleagues (1993), conditioned stimulus–unconditioned stimulus contingencies foster an association between arm flexion and approach motivational orientations. In prior investigations, participants were instructed to flex or extend either both arms at the same time (e.g., Cacioppo et al. 1993), the right arm (e.g., Friedman and Förster 2000; 2002, 2005), the left arm (e.g., Förster 2003, experiment 1), the dominant arm (e.g., Centerbar and Clore 2006), or the nondominant arm (e.g., Förster 2004). To our knowledge, a theoretical rationale for the manipulation carried out (both arms / a single arm, left arm / right arm, dominant arm / nondominant arm) has never been given. The choice for a specific manipulation seems more random than theory driven. We are unaware of research manipulating within the same experiment whether the arm movements are carried out with the dominant versus nondominant hand. Although it is virtually impossible to demonstrate that a learning process over an individual's lifetime is responsible for the establishment of these contingencies, the fact that the effect of arm flexion on present-biased preferences via BAS activation is stronger for the dominant arm, certainly lends credibility to that claim. The absence of effects of ‘leg flexion’ (Cacioppo et al. 1993) and ‘arm flexion of the nondominant hand’, suggests that the differential effects of arm flexion and extension are attributable to the countless repetitions over an individual's lifetime of the pairing of muscle contractions with differential evaluative outcomes. Nevertheless, future research is needed to resolve the inconsistency with studies demonstrating effects of arm flexion of the nondominant arm (e.g., Förster 2004). Presumably, associations between motivational tendencies and somatic actions of the nondominant arm can be established, provided they occur frequently enough. Still, if learning principles are underlying the effect of somatic actions, we would hypothesize that arm flexion of the dominant arm produces stronger effects than flexion of the nondominant arm.

Next to the theoretical contributions of this research (i.e., effects of arm positions beyond attitude formation and cognition; the role of motivational systems in the effect of arm positions and the role of conditioning in establishing higher-order associations between muscle contraction and BAS activation), the practical implications of this research are significant. As suggested by our pilot study, task-irrelevant somatic activity can have important implications for consumer decision making: Consumers shopping with a shopping basket were more likely to display present-biased preferences than those shopping with a shopping cart. Similarly, simply opening the door of a retailer may affect decision-making in that store. Our findings suggest that pulling a door to enter a building, rather than pushing that door, could lead to purchases of products that entail immediate benefits through activation of approach motivational tendencies. In addition, our studies suggest that slot-machines are designed in a nifty way. Slot-machines for which you need to pull a lever should lead to bigger revenues than slot-machines where you only need to push a button or push a lever. The fact that the lever is located on the right hand side of the slot machine, combined with the fact that most individuals are right-handed, increases the chances of instigating present-biased preferences in slot-machine gamblers.

We believe that understanding why and when consumers weigh immediate benefits more heavily than delayed benefits is important (for example, to understand why we choose unhealthy snacks). The present studies were designed to understand the preference for immediate gratification and its possible antecedents. A limitation of the present research is that we have only focused on the role of arm flexion and the BAS. A complementary set of studies might well be carried out to investigate the consequences of arm extension and the potential role of the Behavioral Inhibition System (Carver and White 1994; Gray 1987, 1990; Torrubia et al. 2001). It is not surprising that arm extension has no effect on intertemporal choice between rewards: Presumably, arm extension engages the motivational system regulating responses towards punishments (i.e., the BIS) and, as a consequence, does not affect choices between immediate and delayed rewards. Future research could investigate whether arm extension makes individuals more likely to buy insurances (i.e., avoiding negative outcomes) or affects the choice between a smaller, immediate fine and a larger, delayed fine. We consider these effects, and the potential moderating role of the BIS and/or arm dominance, as an interesting area for future research.

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TABLE 1

Descriptive Characteristics of Shoppers Samples

	Basket (n=10)	Cart (n=126)
Average number of products purchased	10.6^{a}	32^{b}
Average amount spent (€)	36.1^{a}	74.2^{b}
Average store visit duration (min)	16^{a}	35^{b}
Consumers buying vice products (%)	40^{a}	4.8^{b}

Note.-Different superscripts within a row indicate significant differences ($p \leq .05$).

TABLE 2

Ordered Logistic Regression on Purchase of Vice Products at the Cashier

	[1]	[2]	[3]	[4]	[5]
Shopping support	2.33* (10.33)	2.56* (12.98)	2.28* (9.79)	2.24* (9.43)	3.08* (21.74)
Store visit duration		.001 (1.001)			.004† (1.004)
Amount spent			.03 (1.03)		.13 (1.14)
Number of products purchased				-.038 (.96)	-.106 (.90)
Nagelkerke R^2	.242	.271	.260	.246	.405

Note.-Values in parentheses are ratio-changes.

† $p \leq .10$;

* $p \leq .05$

FIGURE 1

DELAY DISCOUNTING OF A MONETARY REWARD (STUDY 2)

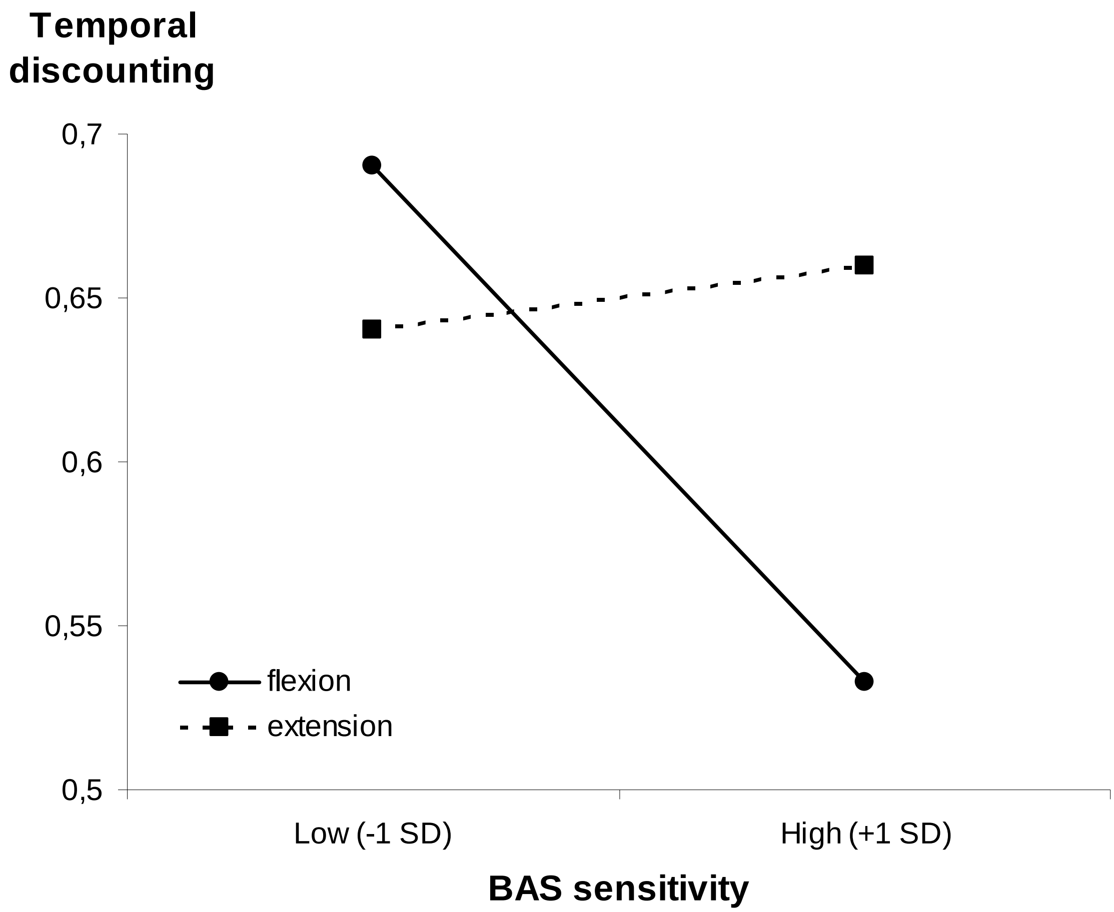

FIGURE 2a

DELAY DISCOUNTING OF A MONETARY REWARD (STUDY 3)

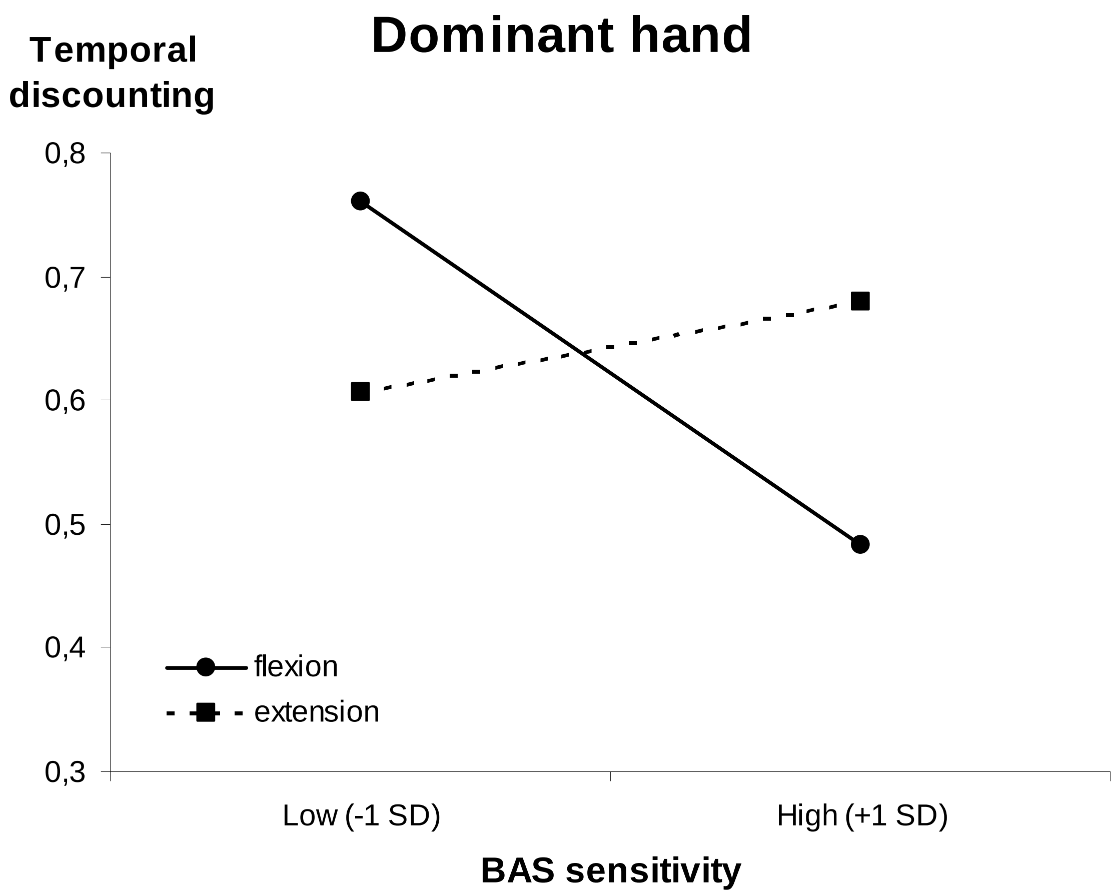

FIGURE 2b

DELAY DISCOUNTING OF A MONETARY REWARD (STUDY 3)

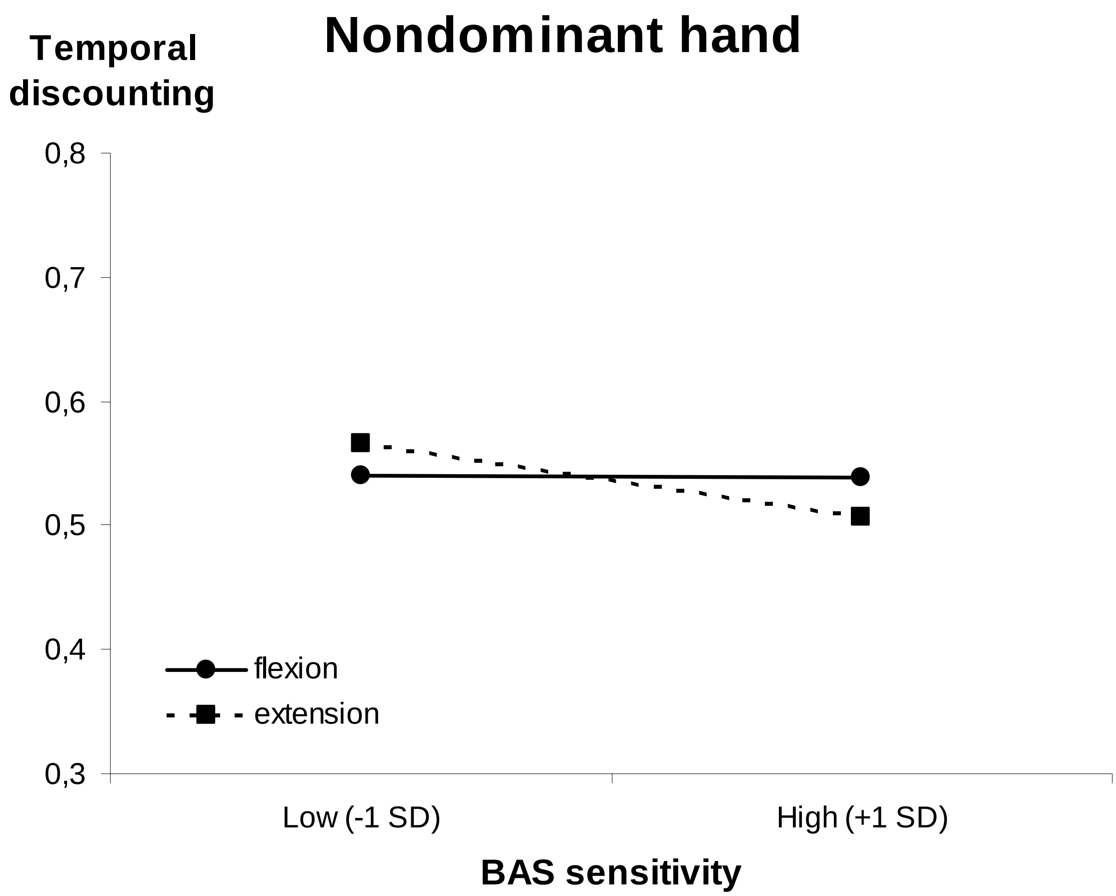

FIGURE 2c

DELAY DISCOUNTING OF A MONETARY REWARD (STUDY 3)