RUNNING HEAD: HEADS OR TAILS

"Heads or Tails?" – A reachability bias in binary choice

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Abstract

When asked to mentally simulate coin tosses, people generate sequences which differ systematically from those generated by fair coins. It has been rarely noted that this divergence is apparent already in the very first mental toss. Analysis of several existing data sets reveals that about 80% of respondents start their sequence with Heads. We attributed this to the linguistic convention describing coin toss outcomes as "Heads or Tails", not vice versa. However, our subsequent experiments found the "first-toss" bias reversible under minor changes in the experimental setup, such as mentioning Tails before Heads in the instructions. We offer a comprehensive account in terms of a novel response bias, which we call *reachability*. It is more general than the first-toss bias, and reflects the relative ease of reaching one option compared to its alternative in any binary choice context. When faced with a choice between two options (e.g., Heads and Tails, when "tossing" mental coins), whichever of the two is presented first by the choice architecture (hence, is more *reachable*) will be favored. This bias has far-reaching implications extending well beyond the context of randomness cognition, and in particular to binary surveys (e.g., accept vs. reject) and tests (e.g., True-False). In binary choice, there is an advantage to what presents first.

Key words: acquiescence bias; order effects; randomness cognition; reachability; response bias

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A typical random binary sequence involves two events (e.g., 0-1, Boy-Girl, Heads-Tails) that are equiprobable and independent. Those studying lay people's ability to generate such sequences have concluded that people are incapable of true mental randomness (e.g., Bar-Hillel & Wagenaar, 1991; Nickerson & Butler, 2009). Compared to sequences produced by random devices, such as tosses of a fair coin, "human produced sequences have too few symmetries and long runs, too many alternations among events, and too much balancing of event frequencies over relatively short regions" (Lopes & Oden, 1987, p. 392). In other words, people's sequences usually manage to reflect the equiprobability of the two outcomes, but not their independence.

While many studies have looked at the properties of entire sequences, few have reported how these sequences begin, none of them in the past 50 years. Goodfellow (1940) reported: "… the probability that an individual will call "heads" on the first toss is … approximately .80" (p. 201); Bakan (1960) reported: "on the very first trial … about 80% of them were H" (p. 130). But researcher attention to the first-toss is the exception, not the rule. Kubovy and Gilden (1991) are more typical. They asked respondents to simulate coin tosses, but attached so little importance to the first toss that they cannot recall which outcome they coded as 0 and which as 1 (Kubovy, personal correspondence).

The neglect of the first toss is somewhat puzzling, because being the sole toss requiring no memory, it has implications for the debate about the role memory plays in subjective randomness. Moreover, if first mental tosses are biased, we don't need entire

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sequences to conclude that people do not generate mental tosses at random. Perhaps first tosses were overlooked because their outcome seemingly "makes no difference", "doesn't matter", or "who cares?". Nonetheless, we wanted to understand what happens in that first toss. Granted it is not generated "at random" -- but how *is* it generated?

Our intuition was that a systematic tendency to begin mental coin sequences with Heads rather than with Tails simply reflects the conventional order in the English language for describing the two sides of a coin: "Heads or Tails", rather than "Tails or Heads" (the former appears in a Google search about 10 times more often than the latter).

In Study 1 we analyzed several existing data sets, demonstrating a striking "first-toss bias" whereby most participants indeed start their guesses with Heads. In Study 2 we report several new experiments in which we manipulated the way participants were instructed to generate their sequences. We meant to understand the conditions underlying the Heads bias, and to rule out the possibility that it was a mere response bias. This, however, was to take a surprising turn when we discovered that the first toss bias could be easily reversed to favor Tails.

Our unexpected results compelled us to posit the existence of a hitherto unrecognized bias, whose relevance extends well beyond randomness cognition. We call it "the reachability bias". In brief, the reachability bias posits an advantage in binary choice to the alternative that is presented first in the spatio-temporal sense (thus, *reached* first), by the respondent. It can be first by linguistic convention, first in the verbal instructions, or first in the response format. In Study 1, these were all aligned, with Heads always first. But when they are not all aligned, as in the many conditions we created in Study 2, there is a hierarchy determining which of them rules. The concept of

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reachability, and the posited hierarchy of reachability effects, did not guide our experiments. On the contrary – they were derived from their results. Hence, its detailed presentation will follow the presentation of the Study 2 results which gave rise to it.

Study 1 – Demonstrating the first-toss Heads bias

Bar-Hillel posted a request to the Society for Judgment and Decision-Making mailing list, asking researchers who had conducted experiments instructing respondents to "simulate a coin", "guess a coin", or similar tasks, to share their data. Peer and Acquisti replied with their own data, as did some other researchers.

Method

Participants: Ten samples in which participants were asked to generate sequences of coin tosses mentally were received. Table 1 summarizes these samples and their demographics (where obtainable). The first five were collected in Pittsburgh. Three were collected in Germany. Sample 9 was collected at Tufts. The 10th sample will be reported in Study 2. We label the samples by the initials of their collectors.

Samples 1-5 include online and offline participants and a diverse set of English speaking subjects. They were recruited on Amazon's Mechanical Turk (henceforth, MTurk). Sample 2 was collected using a "data truck" parked on a main Pittsburgh street. Samples 3 and 4 were recruited from the participants pool of the Center for Behavioral and Decision Research at Carnegie Mellon University, in one online study and one lab study.

Samples 6-8 were fourth year students in the University of Muenster, taking a Behavioral Finance class, who performed the task as part of a classroom demonstration.

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Sample 9 were undergraduates, who participated for course credit, supplying the data for Nickerson and Butler (2009).

Procedure. PAS samples: Participants were shown the screen depicted in Figure 1, and instructed: "The next, and final, section deals with human ability to predict the results of totally random events, such as tosses of a random coin. You will be asked to guess the results of 10 [or, in the case of sample 5, five] coin tosses (guessing Heads or Tails for each toss). For each correct guess that you'll have, you'll earn a bonus of [10 cents for samples 1 and 5; 50 cents for samples 2, 3, and 4]. … For each of the 10 tosses, predict whether the toss will result in Heads or Tails." [1] Afterwards, participants checked their predictions either by tossing an actual coin (sample 4) or by visiting an online random coin-tossing web site (samples 1, 2, 3, 5). They then compared the results of the actual coin tosses to their predictions, and were paid according to the number of correct guesses they reported.

TL samples: For an unrelated class demonstration, respondents in samples 6-8 were asked (in German): "Please generate on this sheet a sequence of 50 outcomes that could stem from random coin tosses (K=heads, Z=number)" (the German equivalent of Heads and Tails, and equally conventional). The sheet showed 2 columns of 25 slots each, numbered 1 to 50, wherein the students entered K or Z.

NB sample: Respondents in sample 9 were asked to "produce 100 10-item random sequences … by typing 100 sequences, each … composed of 10 ones or zeros (representing heads or tails). Participants were asked to imagine that each of 100 people had tossed a coin 10 times and the results had been recorded in a table of 100 rows and 10 columns ... They were asked to produce a table of the same size in such a way that if it

[1] Here and throughout the paper instructions are quoted verbatim.

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were compared with the one that represented actual coin tosses, it would not be possible to tell [them apart] with statistical tests …" (Nickerson & Butler, p. 143).

Results and discussion

Figure 2 displays the results of Study 1. The first-toss bias (solid black bars) favoring Heads is sizable (yet none of the researchers had noticed it). Percent Heads in the first toss ranged between 69% (sample 7) and 84% (sample 3), for a total of 79.3% (weighted; 77.4% unweighted). This percent is almost four times as high as that of Tails, and is consistent with the results of Goodfellow (1940) and Bakan (1960). All percentages were significantly higher than chance ($p < .02$).

The bias was exhibited regardless of respondents' nationality or language, method of subject recruitment, length of the sequence produced, presence or absence of a monetary incentive for accuracy, and whether or not a fixed template was provided for the answer.

The evidence for a Heads bias extends beyond the first toss. We calculated the mean percent of Heads in tosses 2-10 (gray bars in Figure 2). The Heads bias, albeit attenuated, persisted for all 9 samples. Nine Heads biases in nine samples is statistically significant (exact binomial test, $p = .002$), as are the individual biases ($p < .01$; [2] except Sample 9). This bias is even more notable if one considers that respondents, who usually aim for a balanced sequence, should have, on average, given a mean of 53% Tails in tosses 2-10 to balance out an 80% first-toss Heads bias.

Study 2 - Explaining the "first-toss" bias

Study 1 established that people's supposed indifference to the outcome of the first toss nevertheless yields a biased first toss. Study 2's goal was to explore the origins of

[2] Note that these percents are over Nx9 observations in each column.

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this bias. We initially thought that a Heads bias results simply from the conventional order in describing the two possible sides of a coin – "Heads or Tails", not "Tails or Heads". Operatively, however, this can mean several things. i. People start their sequence with Heads because the Heads option precedes the Tails option in the linguistic convention. ii. When instructed to "guess whether the coin would result in Heads or Tails", people start with Heads because the instructions prime them to think of it first. iii. Provided with a response format on which to record their guesses, people mark Heads first because it appears as the first choice.

In the PAS samples, all three possibilities were confounded. In the other samples, which used a neutral response format, only the first two (linguistic convention and instructions) were simultaneously present. Under natural circumstances, such confounding is to be expected, since order in the instructions as well as order on response format would themselves typically follow the conventional linguistic order. But experimentally, it is possible to disentangle them. Study 2 de-confounded these possibilities to determine which cause the first-toss bias.

All participants (but group CO) were recruited on MTurk, and each partook in one experiment. Group assignment was random.

Experiment 1 – The null effect of the accuracy bonus

Before beginning, we wished to free ourselves of some procedural precedents from Study 1 -- in particular, to forgo any accuracy bonus. Study 1 already showed that the first-toss bias did not depend on whether the accuracy bonus was 50 cents or 10: mean percent of first-toss Heads was 80.3% for the low-bonus samples 1 and 5, and

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80.4% for the higher bonus samples 2, 3, and 4. Experiment 1 tested what happens when rewards are removed altogether.

Method

A hundred seventy five participants (58% males, M_{age} = 33, SD = 12) were instructed to predict 10 coin tosses, just as done in Sample PAS-1. Group 1 was told they would be paid 10 cents according to the same procedure used there, while Group 2 was neither given these instructions nor paid.

Results and discussion

Table 2 summarizes the characteristics (first 5 columns) and results (last 3 columns) for all experiments in Study 2. It shows which side, H or T, was more popular on the first toss, and its popularity. Additionally, it shows the percent Heads in tosses 2-10 (numbers rounded to 2 decimals).

Groups 1 and 2 showed a similar first-toss Heads bias: 80.9% of paid participants versus 82.6% of those unpaid (Z = .70, p =.24*)*. Since removing the accuracy bonus certainly did not diminish the first-toss bias, the following experiments abandoned it.

Experiment 2 – The effect of response format

The linguistic convention "Heads or Tails" is a given that cannot be easily manipulated. But tasks asking people to predict coins needn't follow it: instructions can mention either Heads or Tails first, and response formats can show either the Heads or the Tails column first (namely, to the left). In Study 1, order in the instructions and response formats were both aligned with the conventional order in English, namely, Heads first. In Experiment 2, we added three conditions where the instructions, the response format, or both, were not aligned with the natural order.

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Method

We recruited 248 participants (66% males, M_{age}= 29, SD = 9), and used the exact procedure as in Group 2, except for reversing the H-T order in one or in both of the instructions and the response format (see full wording in Table 2).

Results and discussion

All four groups 2-5 showed a statistically significant first-toss bias (exact binomial test, $p < .01$). The favored outcome, rather than always being Heads, was consistently the one listed first (i.e., on the left) on the response format. So, order on the response format trumped the conventional English order, and – importantly - did so regardless of the order in the instructions. The next experiment tested what happens when the response format is order neutral.

Experiment 3 – The effect of the instructions

Recall that PAS samples of Study 1 used a response format that put the Heads column before the Tails column, whereas other samples in Study 1 elicited responses on an order-neutral format. Yet all showed a first-toss bias. Experiment 3 de-confounded the fixed-order convention in the language from the malleable order in the instructions, while using an unordered response format.

Method

We recruited 105 participants (57% males, M_{age}= 32, SD = 10) who, as before, predicted the outcome of 10 coin tosses. Respondents entered their guesses into a single column of ten text-boxes displayed vertically. Group 6 were asked to "enter H for Heads or T for Tails", while for Group 7 the order was reversed.

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Group CO, the tenth data set received from colleagues, followed a procedure similar to that of Group 7. Thirty-four Princeton undergraduates took part in a pilot study, under a "fairly controlled lab setting" (Olivola, personal correspondence), and were told: "Please generate a random sequence of 21 coin tosses, such that heads and tails are equally likely to occur. Write 'T' to represent tails and 'H' to represent heads. Please make an effort to be [sic] produce a sequence that is as close to random as possible." Responses were entered on a dashed numbered line, thus:

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

Note that although the coin's possible outcomes were stated in the conventional order, the concrete instructions referred to Tails before Heads.

Results and discussion

When the instructions referred to Heads first (Group 6), 87% of the participants guessed H first (exact binomial test, $p < .01$), and when they referred to Tails first (Group 7), 68.6% began with Tails ($p = .01$). In the CO group, 64.7% of first guesses were Tails (exact binomial test, $p = .06$). So, in the absence of an ordered response format, it is order in the instructions that determines the direction of the bias. Bias magnitude was significantly higher when directed by the response format (Groups 2-5, $M = 75.7\%$) than by the instructions (Groups 6-15, $M = 68.2\%$; $Z = 2.41$, $p = 0.02$).

Experiment 4 – Changing the coding of the binary outcomes

We were surprised how readily the linguistic convention seems to yield to the order in response format or instructions. Experiment 4 tested the robustness of this

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unexpected evidence by using other coding schemes for the two sides of a coin. It is often customary to code nominal binary outcomes as 0–1, or as 1–2. Groups 8-15 did just that.

Method

We recruited 443 participants (64% males, $M_{age} = 31$, $SD = 10$), who entered their predictions into an order-neutral response screen showing 10 text-boxes arranged vertically, as in Experiment 3. Four numerical coding schemes for Heads vs. Tails were used: 1-0; 0-1; 1-2; and 2-1, respectively. Each was used twice: once when Heads was the option mentioned first in the instructions (e.g., "mark 1 for Heads, 0 for Tails"), and once when it was Tails.

Results and discussion

The outcome mentioned first in the instructions was the outcome chosen by the majority of respondents in the first toss (excepting Group 15). Seven successes out of 8 binary trials is statistically significant (exact binomial test, $p = .04$), and six of them (excepting Group 9, $p = .28$) were also individually significant (exact binomial test, $p < .05$).

Experiment 5 – The pure effect of the linguistic convention

The results hitherto suggest that the conventional order of Heads and Tails in the language causes the first-toss bias only *indirectly,* via determining the common order in instructions and response formats, but is easily trumped by reversing the order in either. To see whether it can also have a direct effect, we removed the mediating order in instructions as well as in the response format. Group 16 were told: "For each of 10 tosses, predict what that toss will result in, and enter your prediction into the boxes" – without mentioning what binary outcomes to use. Thus, any reference to the words Heads and

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Tails could only originate from the participants' own minds, where, we hypothesized, it would follow the conventional order.

Method

Forty nine participants (59% males, M_{age} = 33, SD =11) predicted the outcomes of 10 coin tosses by entering them into the provided boxes. The instructions had no further specifications.

Results and discussion

All participants, unprompted, entered guesses that were either Heads or Tails, or some slight variation of those words (e.g., Head, head, heads, H, h). Fortunately, not a single response was ambiguous, and 81.6% of the participants started with Heads-like responses (exact binomial test, $p < .01$). This is a pure effect of the linguistic convention.

Experiment 6 – Abolishing the linguistic convention

The final experiment tested for a first-choice bias when no conventional order exists between the outcomes, and even when no coins or randomness are mentioned.

Method

We recruited 97 participants (73.2% males, M_{age} =32, SD =11). Group 17 were told: "Imagine a process that produces two outcomes: one is called Orange and the other Purple. Now imagine that the process is run 10 times, each time producing Orange or Purple. Please try to predict the 10 outcomes the process will produce. In each of the following 10 boxes, enter O for Orange or P for Purple." For Group 18 the color order was reversed.

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These colors were chosen because there is no convention about the order in which they should be mentioned, and in a pre-test where participants list 10 colors, they had similar popularity, Purple just preceding Orange.

Another 100 participants (70% males, M_{age} =33, *SD* =12) predicted ten tosses of a coin, colored Purple on one side and Orange on the other (Group 19) -- or vice versa (Group 20). Heads or Tails were not mentioned.

Results and Discussion

The high proportion of first tosses congruent with the color first mentioned in the instructions in groups 17-20 (ranging between 80% and 92%) are consistent with the rest of Study 2 results, as well as with an unpublished 1940 masters thesis cited by Cronbach (1950): Harry Rubin "gave a "guessing" test, in which subjects imagined a tossed coin, and wrote down the way they imagined it would fall. One group was given directions as follows: "Imagine a coin which has an *H* for *High* on one side, and an *L* for *Low* on the other side". In the other group this was reversed. There was a significant preponderance of the first-mentioned response on the first guessed item (i.e., the former group tended to say "*H*"; the second group to say "*L*")" (p. 11). Alas, Cronbach cites no numbers.

Discussion of Study 2

A coherent picture of the source of the first-toss bias emerges from Study 2. Most people start their sequences with whatever outcome is easiest or most accessible: When an ordered response format is presented, that is the outcome offered first by the format (all samples of Study 1 and Groups 1-5 in Study 2); when the response format suggests no order, that is the outcome mentioned first in the instructions (Groups 6-15, CO, and

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17-20); when the instructions too suggest no order, that is what comes first to mind thanks to the conventional order, namely Heads (Group 16).

Yet the conventional order exerts its influence on the first toss even when the Heads bias is reversed. Other things equal, conditions favoring Heads created a stronger bias than those favoring Tails, in each of the seven pairs that differed only in H-T order. Thus, for all groups j=1, …, 7, Group 2j showed a stronger bias than Group 2j+1.

We categorized groups 2-16 and CO according to two factors. One divided them by whether the first-toss bias favored Heads (all even numbered groups) or Tails (the rest). The other divided them by whether participants responded with H and T ("direct coding"; groups 2-7 and CO) or whether they converted H and T to numbers ("indirect coding"; the rest). Figure 3 shows the first-toss bias using this 2-X-2 categorization. There bias decreases by about 16 percentage points when switching from the natural H-T order to the reversed T-H order ($Z = 5.46$, $p < .01$), reflecting the cost of abandoning the conventional order in the reversed bias (Sample 9 of Study 1 also showed a relatively lower Heads bias – 70%; its respondents coded H and T into 1 and 0). Incidentally, there is also a reduction of about 10 percentage points for indirect versus direct coding ($Z = 3.47$, $p < .01$). There was no interaction ($Z = .37$, $p = .35$).

As in Study 1, tosses 2-10 again provide evidence of a net Heads bias that persists even under reversed instructions. Thirteen of 17 groups (exact binomial test, $p = .03$) show a Heads bias in tosses 2-10. Thus, even when the first-toss bias favored Tails, the Heads bias was reinstated as the sequence evolved.

General Discussion

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We initially set out to study a hypothesized "first-toss Heads bias". On the way we encountered another bias – unexpected, but more general and potentially more important: a bias favoring the first-presented option, be it Heads *or* Tails. Our study was originally motivated by the desire to examine how people generate first mental coin tosses. The paucity of research on this question was a lacuna which this paper fills.

Having established the Heads advantage in Study 1, we set out to understand its cause. And then things took a surprising turn. Because of stable linguistic conventions, we expected Heads to be a more popular first toss than Tails regardless of superficial task particulars, which are transient and probably not even long retained. We were wrong: those very particulars carried the day. Once the response format or verbal instructions put Tails before Heads, a first-toss Tails bias ensued.

We were not wrong, however, about the linguistic bias. We just underestimated its fragility. Reversing the conventional word order in the task setup was sufficient to overcome the effect of the entrenched order in the culture. Apparently, when respondents subjectively generate the first toss in a sequence – the one whose value nobody ostensibly cares much about – they yield to whatever nudge exists in the task particulars. These nudges will themselves usually be biased according to the language; but if not, they easily overturn the language bias.

Yet the influence of the conventional order – which alone determined the first-toss bias when the task was devoid of all nudges (Group 16) – was still detectable. It showed up in later tosses, whether the first-toss bias favored Heads or Tails, and it reduced the magnitude of the first-toss bias when the nudges favored Tails. The latter may be due to a disruption of the generating process apparently brought about by

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violating linguistic convention. This violation adds noise to the first-toss production, making it less predictable. This is quite analogous to the disruption that violating conversational conventions causes when respondents answer "for-or-against" type attitudinal questions (Holbrook, Krosnick, Carson & Mitchell, 2000); there, too, posing the question in the unconventional "against-or-for" order renders responses less predictable.

This brings us to a more general, and potentially more important, bias. As explained in the Introduction, we named this bias *reachability*. Unlike *availability* – which refers to ease of coming to mind (Tversky & Kahneman, 1971), and unlike *accessibility* – which refers to associative strength (e.g., Fazio et al., 1989), *reachability* is a feature of the choice architecture of the task, and not of the mental architecture of memory. Reachability is a spatio-temporal notion, not a cognitive one. In its purest form, reachability can be measured in objective physical units: A is more reachable than B if it is closer to the agent in time or space. This links reachability to primacy effects: in both space and time, when objects are ordered linearly, the closer one is necessarily reached first.

Our data suggests the existence of an order-dependent binary response bias that confers an advantage on whatever response presents first. The existence of an order bias in the language is in this regard but one particular instance. The environment can affect the reachability of responses in other ways as well. Spatial order in the response format is one. Temporal order in the instructions is another.

Rozin et al. (2011) surveyed many studies showing that slight improvements in the ease of reaching for some option increase the chances that it will indeed be reached

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for. In their study, putting a salad item under the sneeze guard in a salad bar decreased its popularity as compared to placing it on the periphery of the salad bar – a more reachable (or, in their terminology, more accessible) location.

The concept can be extended from the physical to the mental world. Thus, the 5th word in the Star-Spangled Banner is less mentally reachable than the first: even if one knows the anthem by heart, most people can't reach "see" without going through the first four words. Similarly, the fact that "Heads or Tails" is more common than "Tails or Heads" is a feature of the linguistic environment which usually makes Heads the more reachable prediction for a coin toss; one normally has to pass through Heads to reach Tails, but not vice versa. Something can be more reachable in the outside world without affecting either its accessibility or its availability in memory, and vice versa.

In the present study, there appears to be a hierarchy of reachability considerations determining the direction and magnitude of the first-toss bias. Motor reachability tops the hierarchy: if one response is more reachable in terms of the motor response required, it will be favored. Such is the left-side column when an English reader has to select which column to mark. Absent a motor bias, the response mentioned first in the instructions is favored, though slightly less. If instructions are unbiased, the response that first comes to mind (first – but not necessarily more readily) is favored -- and the linguistic environment gives Heads priority.

Another nice example of the various possible manifestations of a reachability effect appears in Kim, Krosnick and Casasanto (2013): " … participants read about … two hypothetical candidates and voted for them in a simulated election on which candidate name order was varied. The expected [primacy] effect appeared, and was … greater

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among left-handed [than among right-handed] people when the candidate names were arrayed horizontally, but there was no difference … when the names were arrayed vertically" (p. 1). Thus, appearing earlier on the list had an advantage (this is temporal reachability); and when the earlier names appeared to the left of the later names, their advantage -- for left-handed people only! -- was even more pronounced (this is spatial-motor reachability; see also Linkenauger et al., 2009).

The psychology literature is replete with various kinds of so-called response-set effects, some of which relate to order. Order effects can refer to order in time (e.g., primacy versus recency) or in space (e.g., top versus bottom). Whilst reading, time and space are inevitably confounded. In English, for example, one habitually reads from left to right and from top to bottom. Order of stimulus presentation affects many dependent variables, such as learning and memory, or choice and preference. The response bias encountered here can be classified as a primacy effect in binary choice. Respondents faced with exactly two first-toss possibilities: Heads or Tails (or, on occasion, Tails or Heads). They showed a marked primacy effect: their choices leaned heavily towards the possibility presented (namely, reached) first.

Bar-Hillel (2011) surveyed a literature on what she termed "Location biases in simultaneous choice". Simultaneous choice is choice when all options are present. Thus, choosing a dish in a buffet is simultaneous choice, whereas choosing a performer in an audition is not. When the simultaneously presented options are physical objects identical except for their positioning, such as soup cans on a supermarket shelf or toilet-paper rolls in a bathroom, objects placed in the middle of the array enjoy an advantage, called "middle bias". Christenfeld (1995) wrote that: "It is possible … though quite speculative,

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that minimizing mental effort is the common principle" (p. 55). We might add that physical effort, too, may well be minimized when orienting and reaching towards the middle of such an array. This middle response bias, then, is in the same spirit of reachability as the one discovered in the present study: Other things equal, that option benefits which is easiest to reach for. When facing three or more material objects in parallel, the middle is most reachable. When facing two verbal options in sequence, the first is more reachable.

Choosing which of two columns to mark first, or which of two letters to enter first into a column or a row, can be regarded as forms of simultaneous choice, but Bar-Hillel (2011) excluded binary choice. Order effects in binary choice are harder to find in the literature, especially among physical objects. A recent exception is Carney and Banaji (2012), who found a "First is best" effect in binary choice. But their stimuli were presented separately in rapid succession rather than simultaneously, and for all their purposes could just as well have been choice from 3 or more options.

On the other hand, the literature on surveys, tests, and questionnaires has long noted a particular binary bias, favoring positive terms over their negative counterparts (Yes vs. No; Agree vs. Disagree; True vs. False; For vs. Against; and more). The so-called "acquiescence response set" (e.g., Ray, 1983), or "agreeing response set" (e.g., Couch & Keniston, 1960) is a semantic one. Many explanations have been offered for it, but as with Heads-Tails, it is notable that the bias is also built into the language through the convention of always listing the positive term of a word pair first (Cooper & Ross, 1975) – just try reversing the order in the pairs listed above to appreciate how unnatural it sounds. Indeed, a Google search shows that "yes or no" leads "no or yes" by over 100

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times; “true or false” leads “false or true” by almost 30 times; “agree or disagree” leads “disagree or agree” by about 3 times. Following the linguistic convention confounds the semantic bias with an order bias. In other words, the ubiquitous acquiescence bias may well be a reachability bias.

Our results may have implications for surveys extending beyond acquiescence bias. Krosnick (1999) states that “people answer yes/no and true/false correctly more often when the correct answer is yes or true” (p. 553). We venture to speculate that people would answer yes/no and true/false questions – whether general knowledge ones or attitude ones – more often in the affirmative when the options are “Yes or No” or “True or False” than had they been “No or Yes”, or “False or True”. For example, “I plan to vote in the coming elections”, as well as “New York City is the capital of New York State”, might get more endorsement from respondents instructed to mark Yes or No, where the primacy effect and the acquiescence effect are aligned, than from respondents instructed to mark No or Yes, where they are not.

What about pure (namely, not confounded with semantics) order biases in binary choice? In a study of impressive dimensions and sophisticated methodology, Miller and Krosnick (1998) garnered real-life evidence for a primacy effect in votes received in different name orders in a multitude of assorted 2-candidate US races. “Nearly all (95%) of the [57] significant effects for the two-candidate races were primacy effects (i.e., cases wherein candidates received more votes when listed first than when listed last; …) … Three-quarters of the [61] non-significant differences … were [also] in the direction of primacy effects.” (p. 308).

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There is, of course, no reason to expect that, in normal binary choices, biases would be as large as those we found. In choosing whether to start a sequence of coin tosses with Heads or Tails, people ostensibly attach no importance to the choice and therefore supposedly don't monitor or control it. Since System 1 mental processes (that are intuitive and automatic) bring Heads to mind before Tails, and since there is no reason for System 2 processes (which are deliberative and thoughtful; see, e.g., Kahneman & Frederick, 2002) to interfere with whatever first comes to mind, many respondents start their mental sequence with Heads. But in real-life questions people often have preferences, even strong ones, for one answer over another; the stronger the preference, the weaker the bias. A direct generalization from Miller and Krosnick (1998) suggests that in choices such as making a first-toss prediction, where there would seem to be no good intrinsic reason to guide the choice, order biases are likely to be more marked than in voting. At the magnitude of bias we found, marked indeed it was! Miller and Krosnick (1998) note with respect to their much smaller bias that "the magnitude of name-order effects observed here suggests that they have probably done little to undermine the democratic process in contemporary America" (p. 291-292). But in some contexts even small biases can sometimes matter, and in less important contexts, sheer bias magnitude may endow it with importance.

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Table 1 – Characteristics and results of the samples in Study 1.

Sample	Source	N	% male	Mean age (SD)	Sequence length	Accuracy bonus
1-PAS [a]	MTurk	2238	62	29 (10)	10	10 cents
2-PAS	Data Truck	229	57	31 (13)	10	50 cents
3-PAS	CBDR online	195	34	27 (10)	10	50 cents
4-PAS	CBDR lab	67	58	28 (9)	10	50 cents
5-PAS	MTurk	93	72	27 (7)	5	10 cents
6-TL [b]	2004 class	138	~70 [c]	~22 [c]	50	None
7-TL	2005 class	168	~70 [c]	~22 [c]	50	None
8-TL	2006 class	161	~70 [c]	~22 [c]	50	None
9-NB	Nickerson & Butler (2009)	30	-	-	100x10	None

[a] These samples were collected for some of the studies described in Peer, Acquisti & Shalvi (in press).

[b] Thomas Langer, unpublished data

[c] Estimates by TL of the student population of his samples.

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Table 2 - Characteristics and results of Study 2 groups.

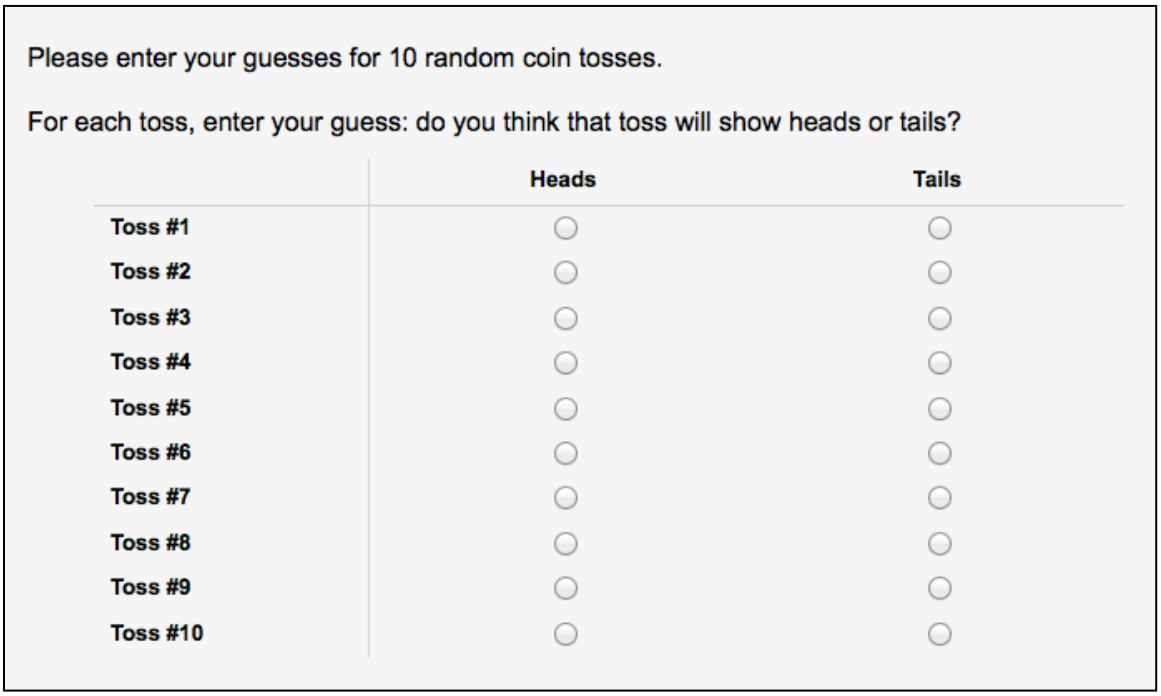
Exp	Group	N	Instructions	Response format	Modal first response	% 1st toss bias*	% H in tosses 2-10
1	1	89	With bonus for accuracy	H first	H	81	61
1	2	86	No bonus for accuracy	H first	H	83	53
2	3	100	Predict by marking Tails column, or Heads column	T first	T	71	52
2	4	63	Predict by marking Tails column, or Heads column	H first	H	84	57
2	5	85	Predict by marking Heads column, or Tails column	T first	T	66	51
3	6	54	Enter H for Heads, T for Tails	Neutral	H	87	54
3	7	51	Enter T for Tails, H for Heads	Neutral	T	69	53
3	CO	34	Enter T for Tails, H for Heads	Neutral	T	65	51
4	8	63	Enter 0 for Heads, 1 for Tails	Neutral	H	84	54
4	9	45	Enter 0 for Tails, 1 for Heads	Neutral	T	56	55
4	10	50	Enter 1 for Heads, 0 for Tails	Neutral	H	76	53
4	11	52	Enter 1 for Tails, 0 for Heads	Neutral	T	64	47
4	12	50	Enter 1 for Heads, 2 for Tails	Neutral	H	74	50
4	13	51	Enter 1 for Tails, 2 for Heads	Neutral	T	63	50
4	14	64	Enter 2 for Heads, 1 for Tails	Neutral	H	63	49
4	15	68	Enter 2 for Tails, 1 for Heads	Neutral	None	50	55
5	16	49	Enter your guesses below	Neutral	H	82	52
6	17	48	Enter P for Purple, O for Orange	Neutral	P	88	48[a]
6	18	49	Enter O for Orange, P for Purple	Neutral	O	80	49[a]
6	19	51	Enter P for Purple, O for Orange	Neutral	P	92	48[a]
6	20	49	Enter O for Orange, P for Purple	Neutral	O	82	49[a]

* All percentages but for groups 9, 15, and CO, differ significantly from 50% (exact binomial test, $p < .05$);

[a] Mean percent of "Purple".

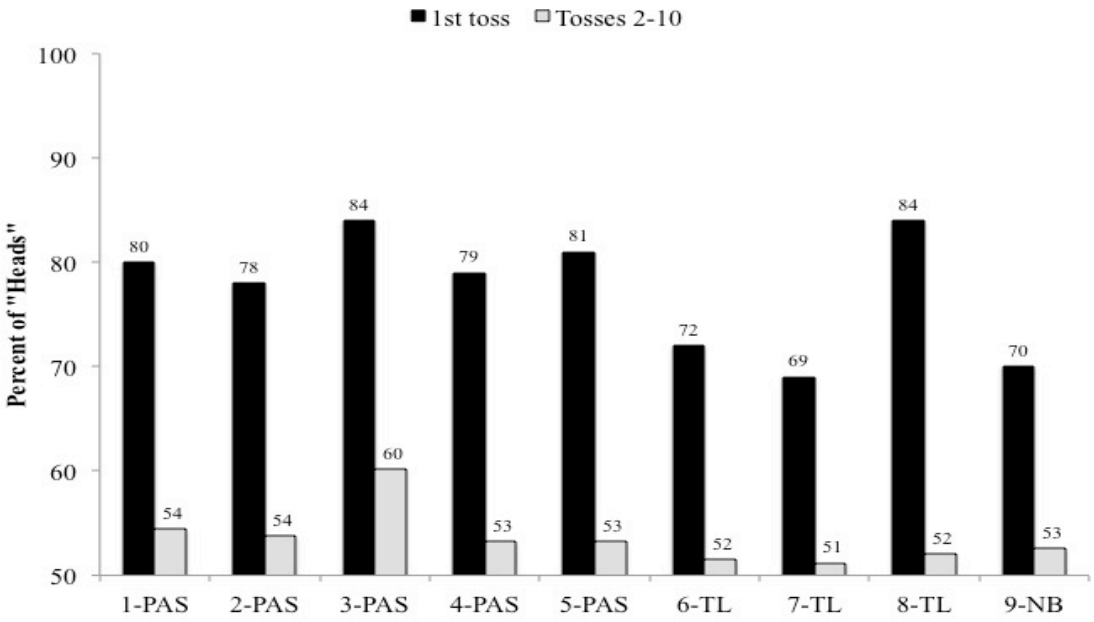
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Figure 1. A screenshot of the response format in the PAS samples.



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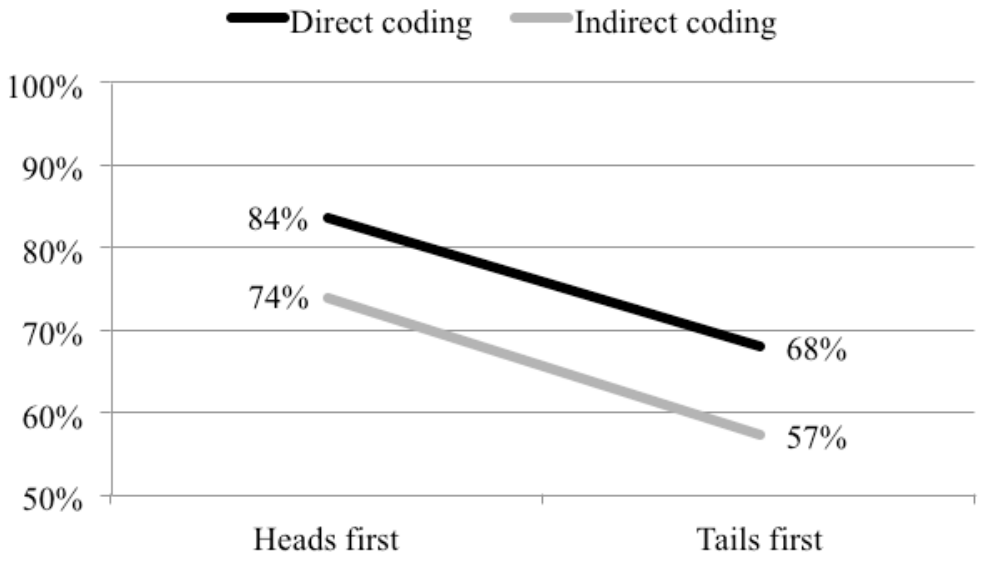
Figure 2. Percent Heads in first toss, and mean percent Heads in tosses 2-10, for Study 1 samples [a]



[a] Tosses 2-5 in 5-PAS

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Figure 3: Percent of first-toss bias in Study 2, according to coding scheme and experimental H-T order



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