Do Choices Affect Preferences?

Some Doubts and New Evidence

Steinar Holden
Department of Economics
University of Oslo
Box 1095 Blindern, 0317 Oslo, Norway
Steinar.holden@econ.uio.no
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Abstract

When testing for the existence of choice-induced changes in preferences, one is faced with the combined problem that the preferences are measured imperfectly and that the choice reflects the true preferences. The upshot is that the choice yields information about any measurement errors, implying that the choice may predict a change in measured preferences. Previous studies have neglected this effect, interpreting a change in measured preferences as a change in true preferences. This paper argues that the problems with previous studies can be mitigated by eliciting more information about the preferences of the participants prior to the choices. The paper reports results from a novel experiment, where the evidence does not support the existence of a choice-induced change in preferences.

Keywords: choice-induced changes in preferences, post-decision dissonance, cognitive dissonance, choice, carry-over effects

Introduction

There is a long held view among social psychologists that the choices people make affect their preferences. One possible source of this could be cognitive dissonance (Festinger, 1957). Testing for this effect, a number of studies have found that after being asked to make a choice, people's rating of their chosen alternative tends to improve, while the rating of the rejected alternative tends to deteriorate (see e.g. Brehm, 1956; Festinger, 1964; Lieberman, Oschner, Gilbert, & Schacter, 2001). This "spreading of ranking" has been interpreted as evidence for choice-induced change in preferences, and also as examples of the broader phenomenon of cognitive dissonance reduction.

However, when testing for the existence of choice-induced changes in preferences, one is faced with the combined problem that the preferences are measured imperfectly, and that the choice reflects the true preferences. Even if there is noise in the choice, the fact that the choice also reflects true preferences implies that it will also yield information about any noise or errors in the measurement. Thus, if preferences are measured a second time, a change from the first might reflect noise in the first measurement, and thus be predicted by the choice. For example, if John has first ranked chocolate above ice cream, but then chooses an ice cream rather than a chocolate bar, the choice makes it less likely that John really likes chocolate better than ice cream. If John is once more asked to rank chocolate and ice cream, it would seem more likely that the ranking were reversed than it would have done if John also had chosen the chocolate bar rather than the ice cream.

If the information effect is not taken into account, one may falsely interpret a change in measured preferences that is predicted by a choice, as a change in actual preferences that is caused by the choice. Furthermore, this also implies that it is difficult to test for whether there actually is a change in preferences caused by the choice.

An example is a recent paper Egan, Santos and Bloom (2007), who use the free-choice paradigm of Brehm (1956) to test for cognitive or post-decision dissonance among preschoolers. The authors find that when children are repeatedly faced with a choice between two items (in this case stickers) that the children previously had given the same rating of liking, a sticker that is not chosen in one choice against another sticker has a lower tendency of being chosen in a subsequent choice against a third sticker. Egan et al interpret this as a change in preferences, that the unchosen sticker has been viewed as less valuable because it was not chosen, i.e. as evidence for post-decision dissonance, or, following the terminology of Sagarin and Skowronski (2008), as a psychological carry-over effect.

However, as pointed out independently by Chen (2008), Chen and Risen (2010) and in a previous version of the current paper (Holden, 2008), this interpretation neglects that the choice also incorporates additional information about the preferences. Even if a child has given the two stickers the same rating of liking, he or she may not be indifferent between the two. The child is likely to prefer some stickers rather than others, even within the same rating of liking. The fact that a child chooses one sticker over another, provides information that the former sticker is likely to be better than an average sticker with the same rating, while the unchosen sticker is likely to be inferior. This also implies that the unchosen sticker is likely to be inferior to a third sticker with the same ranking, even without a change in preferences. Thus, a tendency of choosing the third sticker need not imply preference change. The same problem also arises in other tests of choice-induced attitude changes – the true cause of the results may well be that the choices yield more information about the preferences, and not that preferences change.

In this article I first explain the experiment of Egan et al and the problem with it. I then report results from a modification of their experiment, which is designed to avoid this problem. The underlying idea is that the problems with previous studies can be avoided or at least mitigated by eliciting more information about the preferences of the participants prior to the choices, so that the choice itself provides less information. The evidence does not support the existence of a choice-induced change in preferences.

A free-choice experiment

The goal of Egan et al (2007) was to explore whether children and monkeys displayed choice-induced changes in attitudes, with the underlying motivation being to better understand the causes of such changes. To this end, Egan et al undertook a variant of the Brehm's (1956) free-choice paradigm. The experiment had three phases. In the first phase, 30 4-year-old children were shown a number of commercially available foam stickers of various shapes. The children were asked to rate the stickers using a smiley-face rating scale with six rating levels. The rating identified a number of *triads*, that is, three stickers that a child had given the same rating. In the second phase, each child was given the choice between two stickers from a triad. The chosen sticker was labeled A, and the unchosen B. In the third phase, the child was given a new choice between the sticker not selected in the first choice (sticker B), and the third sticker from the triad, C.

The idea with the experiment was to test whether the first choice affected the second in the same way as in previous studies: the act of rejecting sticker B in the first choice would lower its value, making the children more likely to choose the novel sticker C in the second choice. Egan et al also included a control group (no-choice group), where the children simply received one of the first pair of stickers, and then subsequently were allowed to choose between the remaining sticker and the third novel sticker. In this control group there would be no reason for any change in preferences, implying that the novel sticker should be chosen in 50% of the cases, as the stickers in the same triad had the same smiley face rating. If there were a difference between the groups, this would indicate that the choice affected the preferences.

In the experiment, the children in the choice-group chose the novel alternative, C, in 63% of the cases, while in the no-choice group, C was chosen in only 47% of the cases. The difference was statistically significant, and the authors interpreted this as evidence for a change in preferences: even if the stickers ex ante were rated as equal, the children that had already rejected sticker B would value it less, and thus tend to choose the novel sticker.

However, an alternative interpretation of the results is that the children also prior to the choices have a ranked preference ordering for the stickers, in spite of the stickers having the same rating. A ranked preference could result from the children having a finer preference scale than six levels. Ex ante, there would be six possible rankings of the three stickers: (where I use “>” to indicate “better than”)

A > B > C

A > C > B

B > A > C

B > C > A

C > A > B

C > B > A

However, a choice of A over B would indicate a prior preference for A over B, which would be inconsistent with the three rankings where B is preferred over A. This would leave only three possible rankings: [A >B > C], [A > C > B], [C > A > B]. We observe that in two of these, C is ranked above B, implying that there is now a 2/3 probability that C is preferred to B. Thus, it follows that without any change in preferences, one would expect the participants to prefer the third sticker C in 2/3 or 66.7% of the cases, rather close to the experimental outcome from Egan et al’s study of 63.0%. The intuition here is that while A, B and C are equally attractive in expected terms ex ante, the fact that a child prefers A to B provides new information that A is likely to be somewhat more attractive, and B somewhat less attractive. Thus, participants are likely to prefer A over C (with probability 2/3), and C over B (with probability 2/3), cf. the possible rankings above. This is the basis for the critique in Chen (2008), Chen and Risen (2010) and Holden (2008).

Note that a similar problem also applies to tests of post-decision dissonance or choice-induced attitude changes based on a ranking of items (some examples of a large literature are Brehm, 1956, Gerard & White, 1983, Steele, 1988, Lyubormirsky & Ross, 1999, and Lieberman, Ochsner, Gilbert & Schacter 2001); see also the critique in Chen and Risen (2010). Typically, when participants have ranked a number of items, they are faced with a choice between two items with similar rank, say 6 and 7. After the choice, the participants are once more asked to rank the same items. It turns out that the second ranking is usually somewhat different from the first ranking, as some items improve their ranking and others fall. More importantly, there is usually also a tendency that chosen items improve in ranking, and rejected items fall. This effect, often referred to as a post-decisional spreading, is interpreted as a change in preferences induced by the choice.

However, an alternative interpretation is that the choice gives additional information about the preferences over the items. The key point is that the first ranking does not give a perfect measurement of the preference – we know this because in experiments a new ranking usually leads to a change in the ranking, even without any intermediate choice, implying that at least one of the rankings musts be an imperfect measure of the preferences. When the ranking is imperfect, the choice gives additional information about the preferences, which then helps predict the changes in the second ranking.

For example, if John has first ranked chocolate above ice cream, but then chooses an ice cream rather than a chocolate bar, this makes it less likely that John really likes chocolate better than ice cream. Thus, if John is once more asked to rank chocolate and ice cream, it would seem more likely that the ranking were reversed than it would have done if John also had chosen the chocolate bar rather than the ice cream.

This critique has important bearing on applications of the general idea of post-decisional dissonance. For example, some studies find that participants from Eastern cultures exhibit less post-decisional spreading than participants from Western cultures (Heine & Lehman, 1997, Hoshino-Browne, Zanna, Spencer, Zanna, Kitayama & Lackenbauer, 2005). However, as pointed out by Chen and Risen (2010), this difference could also reflect that the first ranking gave better information about the preferences for the participants from Eastern cultures, in which case the choice would involve less novel information and thus have less predictive power on the subsequent ranking.

The critique, as formulated by Chen (2008), has been opposed by Sagarin and Skowronski (2009). They argue that also choices are imperfect, implying that the fact that a child chooses sticker A over sticker B does not necessarily imply that A is preferred over B. If there is noise in the choice, the probability of choosing sticker C in the second choice becomes lower than 2/3 (see explanation below). The critique has also led to new experiments designed to avoid the problem. Chen and Risen (2010) redesign the experiment so as to circumvent the problem; see also discussion in Risen and Chen (2010). Egan, Bloom and Santos (2010) consider the effects when the participants choose between objects they cannot see, implying that any effect on subsequent choices cannot be caused by prior preferences between the objects. Egan et al find a clear effect of the participants' first choice on their second, in the sense that the objects rejected in the first choice were less preferred in the second choice, consistent with a carry-over effect.

Egan et al's (2010) study is a good illustration of the problems associated with constructing a test which avoids that the choice reflects preferences. On the one hand, Egan et al's proposal is ingenious, as a blind choice clearly ensures that the choice is unaffected by the preferences, thus making a clean test of any carry-over effect. On the other hand, the test is made in a very specific setting, where the participant makes a choice between two objects without any information about their characteristics. It is not clear that a carry-over effect will be the same after a choice where the participant has seen the two objects, and thus made a comparison, as when the choice is made without seeing the objects. Thus, to what extent the result of Egan et al (2010) can be extended to other choice settings remains open. The present paper suggests a different route to explore the issue.

The novel approach

Chen and Risen (2010) and Sagarin and Skowronski (2009) point out that if there is noise in the choice process, the predicted probability of choosing the novel sticker C is lower than 2/3, and closer to 0.5 the more noisy the choice is. Without knowing the amount of noise, one cannot know the probability of choosing C with constant preferences. Thus, one is also unable to test whether the choice affects preferences.

The idea of the current study is to better control for the amount of noise in the choice process. Controlling for the noise, it would be possible to predict the propensity for choosing the novel sticker C under constant preferences, and thus also test for possible changes in the preferences.

Specifically, I assume that the preferences of the children can be characterized by a "minimum distance model" as follows: The children's liking or utility of the stickers can be measured along a continuous scale, so that there in principle is always a perfect ranking. If the difference in liking between two stickers is greater than a minimum distance of preference, $q>0$, the child is assumed to always choose the sticker which gives the higher utility. (The consequences of noise in this choice are discussed below.) However, if the difference in liking is less than the minimum distance, the child chooses the sticker with higher utility with a probability which is lower than unity, ie the choice is noisy. To elicit the preferences of the children, the children are asked the following question before their choice: “Do you like these stickers equally much, or do you like one sticker better than the other?” If the children respond that they like one sticker better, I assume that the difference in liking is greater than the minimum distance, while if they respond that they like the stickers equally much, the difference in liking is assumed to be less than the minimum distance.

The key point of the current approach is that the answer to whether the child likes one sticker better provides a lot more information about his or her preferences, allowing for much tighter prediction of the choice under constant preferences. Comparing the actual choices with the predicted choice under constant preferences, one can then test for any change in preferences.

To conduct a formal statistical test for possible choice-induced changes in preferences, it is necessary derive the probability that a child chooses the novel sticker under constant preferences, conditional on the answer to the question of liking. To this end a formal model for the choice and preferences of the children is presented in the appendix; here I will only state the main points. The utility or liking of the stickers, conditional on the smiley face rating, is assumed to be uniform. Uniform distribution is important for tractability, and it also seems reasonable as a rough approximation to the distribution within one rating level. Common distributions with tails, eg the normal distribution, within a rating level, would give an unappealing shape for the overall distribution for all rating levels. The parameter for the minimum distance in liking required for the children to say that they like one sticker better, will be calibrated on the basis of the proportion of responses in which children say that they like the stickers equally much. For the noise, I explore different parameters values. As in the study of Egan et al, a propensity to choose the novel sticker that is higher than the model’s predictions under constant preferences will be interpreted as indication of choice-induced attitude changes.

Experiment

43 4- and 5-year-olds participated in the study, 20 girls and 23 boys. Children were recruited from three preschools in the Blindern area, in Oslo, Norway. They were tested in their preschool, while sitting at a desk across from the experimenter.

The children's preferences for different stickers were assessed using a smiley-face rating scale that included five faces, from sad to very happy, corresponding to five levels of liking.[1] While many of the children already were familiar with smiley-faces as a measure of liking, the experimenter nevertheless ensured that all understood the scale. This was confirmed by appropriate responses to three queries by the experimenter: "Let's say I like a sticker a whole lot/not at all/somewhere in the middle. Which face should I put it with?"

When the children had shown that they understood the rating scale, they were presented with stickers one by one and asked to match to the faces. We used commercially available adhesive foam stickers with various pictures and shapes, like faces, animals, stars, etc. Most children rated all the 30 stickers presented to them, but 5 became fatigued and stopped earlier. One child rated only two triads, i.e. two times three stickers with the same rating level, while the other children rated at least five triads.

The next phase was conducted by another experimenter, to avoid the children being questioned repeatedly by the same person about their preferences over the same stickers. Each child was given the choice between two stickers, A and B, randomly chosen from a triad. The stickers were put on a plate in front of the child, and the experimenter asked "Do you like these stickers equally much, or do you like one sticker better than the other?" When the child

[1] Experience from an earlier experiment suggested that five levels is enough, and that many children had problems with making use of a grading scale with more levels. While this departs from the specification in Egan et al (2007), who use six levels, this was viewed as less important, as the interpretation of the results does not hinge on any comparison with the results of Egan et al (2007).

had responded to this question, he or she was asked which of the stickers he or she would like to take home. (Chosen stickers were put in an envelope bearing the child's name, to be taken home at the end of the day.) Next, the child was again presented with two stickers, this time the unchosen alternative (which we refer to as B) and the third sticker in the triad, C. Again, the experimenter asked "Do you like these stickers equally much, or do you like one sticker better than the other?" When the child had responded to this question, he or she was asked which of the stickers he or she would like to take home, and the chosen sticker was put in the envelope. This process continued until the child had chosen between all the triads.

Note that asking the children to compare two specific stickers at a time differs from the approach made in past studies of carry-over effects. The motivation for doing this is to ensure a more accurate measurement of the preferences of the children. In an initial rating of many stickers according to a predefined rating scale, there may be a problem if the children have a finer rating than the scale, or that the children are unable to use the rating scale in a consistent way over time. If children are asked to rank a number of different items, this may force them to rank items that they find equally attractive. Furthermore, it may be more difficult to rank many items at the same time, rather than comparing just two items.

A potential problem with asking the children to compare two items is that it may affect whether a carry-over effect will take place. In the cases where the children respond that they like sticker A better than sticker B, their response may make them perceive the choice to be an easy choice between two different stickers, in which case no carry-over effect need occur. However, one should recall that the choice is between stickers previously given the same rating, so there should not be a big difference in the liking of the stickers. Moreover, the same argument also applies to much of the previous research on post-decision dissonance, which examines shifts in ratings or rankings after a choice between two closely, but not identically, ranked objects.

Table 1 displays the prediction from the minimum distance model in the appendix for percentage choice of the novel sticker C, under unchanged preferences, for various values of the parameters q (the minimum distance) and z (the probability that the child chooses the sticker giving the higher utility, when the difference in utility is less than the minimum distance). Consider first the upper row L, which applies when the child in round 1 says that s/he likes one sticker better than the other.. If there is no noise in the choice, ie the minimum distance q is zero, then the argument made above implies that the probability of choosing C is 2/3. Row L shows that if the minimum distance is greater than zero, the response that the child likes one sticker better, implies even more negative information about the unchosen sticker B, as the utility of B must be lower than the utility of A minus the minimum distance. Thus, the probability of choosing the novel sticker C is even higher than 2/3 , and increasing in the size of the minimum distance. Evidence of a carry-over effect consequently requires that C is chosen in an even higher share of the cases.

Table 1: Predicted percentage choice of novel sticker C in round 2, with constant preferences, depending on the answer to the question: "Do you like the stickers equally much, or do you like one sticker better than the other?"						
	1	2	3	4	5	6
L	68.2%	68.3%	70.4%	71.2%	71.3%	73.5%
LL	70.2%	70.2%	78.2%	78.2%	87.1%	87.1%
LE	50.0%	50.8%	50.0%	52.7%	50.0%	55.2%
E	50.0%	50.7%	50.0%	52.1%	50.0%	53.3%
EL	50.0%	50.8%	50.0%	52.7%	50.0%	55.2%
EE	50.0%	50.2%	50.0%	50.5%	50.0%	50.9%
q	0.05	0.05	0.15	0.15	0.25	0.25
z	0.5	0.8	0.5	0.8	0.5	0.8
E/T	0.098	0.098	0.278	0.278	0.438	0.438
L indicates answer "Like one better" in round 1, LL indicates answer "Like one better" in both rounds, E indicates answer "Equally much" in round 1, etc. The predictions are calculated on the basis of the minimum distance model in the appendix, where the unconditional distribution for the utility of the stickers is assumed to be uniform on the interval [0, 1]. q is the minimum distance in utility required for the child to say that s/he likes one sticker better; z is the probability of choosing the sticker with the higher utility, conditional on the difference in utilities being less than the minimum distance. E/T is the ratio for the answer E relative to the total number of answers.						

Consider then the information content of a response E that the child likes the stickers Equally well. If the child nevertheless chooses the sticker with higher utility than 50 percent, i.e. $z > 0.5$, this choice gives additional negative information about the preferences for the other sticker. However, as is apparent from Table 1, the numerical importance of this information is rather limited. For example, if the child responds E in round 1 (row E), and $q = 0.05$ and $z = 0.8$ (column 2), the predicted percentage choice of C is only 50.7 percent. If the minimum distance is larger, $q = 0.25$, and $z = 0.8$ (column 6), there is more room for variation in the utility of the unchosen sticker, and the choice is more informative, implying that the predicted percentage choice of C is somewhat higher, 53.3%. As above, if the novel sticker C is chosen more often than the model predictions under constant preferences, this would suggest the existence of a carry-over effect.

The relationship between the response to the question in round 2 and a possible carry-over effect is however more difficult to interpret. Presumably, a carry-over effect might also affect children's answer in round 2 as to whether they like one sticker better, in addition to the effect on the choices. Thus, the carry-over effect might lead some children to say that they like the stickers equally well, instead of saying that they like one sticker (sticker B) better, and it might lead some children to say that they like one sticker (sticker C) better, instead of saying that they like the stickers equally much. Thus, a carry-over effect should lead to a higher percentage choice of sticker C after an answer "Like one sticker better" in round 2, but not necessarily to a higher choice of C after the answer "Equally much".

Results

In this section the empirical results are compared with the predicted choice under constant preferences from the minimum distance model. The parameter for the minimum distance, q, is calibrated on the basis of the empirical results, while for z, I display two values, 0.5 and 0.8, so as to illustrate the potential effects.

In total, the 43 children rated 339 triads, i.e. an average of 8.3 triads. In 86 of them, or 25.4 percent, the child responded that s/he liked the stickers equally well in round 1. This ratio is used to calibrate the minimum distance to q = 0.136 (columns 1 and 2), cf. the E/T row. However, as there is considerable variation among the children in how often they respond that they like the stickers equally well, the other columns use other values for q. For triads where the child responded E in round 1, E was also the answer in 39/86 = 45% of the cases in round

2, and this ratio is used to calibrate q in column 4. For triads with answer L in round 1, E was the answer in 30/253 = 12% of the cases in round 2, and this is the basis for the value of q in column 3.

In 253 triads, the child responded that s/he liked one sticker better in round 1 (row L). In this case the model prediction for the propensity to choose C ranges from 68.6% to 70.8% (using columns 1-3, while column 4, which is calibrated from the results after the answer Equal in round 1 seems less relevant). The experimental outcome was markedly lower, 65.6%, with a 95% confidence interval from 59.4% to 71.4%. Thus, there is no indication of a carry-over effect, even if the confidence interval for the empirical propensity includes the range for calibrated model predictions.

The same tendency is even stronger for the large majority of the cases, 223, where the child responded that s/he liked one sticker better in both choices. The predicted choice of C in this case ranges from 70%-77% (columns 1-3), while the empirical propensity is only 64.6%, with a 95 % confidence interval up till 70.8%. Thus, almost the whole confidence interval for the choice of C is below the range for the model predictions. At face value, this is evidence against the existence of a carry-over effect in this case. However, as shown by Chen and Risen (2010) and Sagarin and Skowronski (2009), if there is noise in the choice process implying that the child might choose a different sticker than the one s/he likes best (also after response L), this would push the predicted percentage for C downwards, undermining the statistical significance.

In contrast, for the 30 triads where the child responded that s/he liked the stickers equally much in round 2 (row LE), the empirical propensity to choose C was 73.3%, with 95% confidence interval down till 54%, above the calibrated model predictions which range from 50% to 52.4% (columns 1-3). However, as noted above, the interpretation of this result is not clear; Interpreting it as a carry-over effect would beg the question of why the child responded that s/he liked the stickers equally well in round 2. Yet the high percentage choice of C put some question mark to the reliability of the children's response to whether they like the stickers equally much.

Table 2: Percentage choice of novel sticker C in round 2.

	Empirical sample					**Calibrated model predictions:** C chosen			
	Total sample			First triad for each child					
	# Triads	C chosen	Conf. interval	# Triads	C chosen	1	2	3	4
L	253	65.6%	59.4-71.4	27	63.0%	70.2%	70.8%	68.6%	73.7%
LL	223	64.6%	57.9-70.8	20	65.0%	77.0%	77.0%	70.0%	88.1%
LE	30	73.3%	54.1-87.7	7	57.1%	50.0%	52.4%	51.0%	55.5%
E	86	60.5%	49.3-70.8	16	62.5%	50.0%	51.9%	50.9%	53.4%
EL	47	57.4%	42.2-71.7	10	60.0%	50.0%	52.4%	51.0%	55.5%
EE	39	64.1%	47.2-78.8	6	66.6%	50.0%	50.5%	50.2%	51.0%
E/T	0.254	-	-	0.372	-	0.254	0.254	0.118	0.454
q	-	-	-	-	-	0.136	0.136	0.061	0.261
z	-	-	-	-	-	0.5	0.8	0.8	0.8

Confidence interval is 95 percent interval, based on a binomial distribution. Otherwise see Table 1. Note that LL and LE are the subsamples of L, while EL and EE are the subsamples of E.

As noted above, for 86 of the triads, the child responded that he or she liked the two stickers equally much (row E). 33 children did this at least once. Thus, in this case the round 1 choice gave little information of a prior preference of the stickers, and the model prediction for the ratio of the third sticker C in round 2 would hence be close to 50 %, ranging from

50.0% to 53.4%. In the experiment, the third sticker C was chosen in 52 of the 86 cases, or 60.5%. Thus, the point estimate would indicate a carry-over effect. However, the 95% confidence interval was 49.3% to 70.8%, thus including the predicted choice of C in Table 2. Hence there is no significant evidence for a carry-over effect after a choice between stickers which the child finds equally attractive. The same holds for the 47 stickers for which the children respond E in round 1 and L in round 2 (row EL): the empirical percentage choice of C of 57.4% is above the predicted values of 50.0% - 55.5%, but the difference is not statistically significant at the 5% level in a two-sided test. For the remaining 39 stickers for which the children responded E in both rounds, the empirical propensity to choose C of 64% was considerably above the predicted values 50.0%-51.0%, but again the difference is not statistically significant. However, also here the high propensity to choose C could rather indicate noise in children's response to the question of whether they like the stickers equally well, than a carry-over effect.

I also tested for the possibility that the choices of the children depended on the rating of the stickers, in the sense that children would react differently depending on how much they like the stickers. However, although the point estimates suggested a difference after the answer E in round 1, - that for the most preferred triads, sticker C was chosen in 52% of 48 cases, while for the least preferred triads, sticker C was chosen in 71% of 38 cases – the difference was not statistically significant.

A possible objection to the experiment is that children learn from the course of the experiment that they will be asked to choose between the two stickers, and that this makes them less likely to respond that they like the stickers equally much, so as to avoid a potential inconsistency in their behavior. If children report a clear preference also in some cases where they in fact are indifferent, the choice in round 1 will provide less information and the expected ratio for sticker C in round 2 will be biased towards 50%. Now it is not clear why children should do this, as there is nothing inconsistent in choosing one item when given a choice between two identical items[2]. It seems more likely that as children learn that they will be asked to choose, they become more aware of the difference between the stickers, and thus less likely to say that they like them equally much. If the children become more aware of the differences, the choice in round 1 would give more precise information about the preferences of the children, reducing any possible bias in round 2.

The experiment did indeed show some tendency of changed behavior: for the first triad, the children responded that they liked the stickers equally well in 37% of the cases, while the ratio for the whole sample was 25%; a difference which is significant with p-value 5%. However, the key issue of the experiment – the choice of the novel sticker C in round 2 – did not change much: As can be seen from Table 2, the propensity to choose C is very similar for the first triads as in the whole sample, except for the LE case, where the choice of C dropped to 57.1% from 73.3% in the whole sample. However, this was only seven of the first triads, and cannot be given much weight.

Discussion

The experiment gave no indication of post-decision dissonance or a carry-over effect in the large majority of the decisions, when the children had responded that they preferred one sticker above the other in round 1. The empirical propensity to choose the novel sticker was 65.6%, considerably below the range of predicted propensity of 69%-71%, based on the calibrated model under constant preferences. Indeed, in the cases where children responded that they liked one sticker better in both choices (row LL), the novel sticker was chosen in 64.6% of the cases, with confidence interval 58%-71%, almost entirely below the range for

[2] To the contrary – the irrational behavior would be to be unable to choose between identical objects – the reader may recall the paradox in philosophy with Buridan's ass, who placed exactly between two equal haystacks, could not decide which to turn to in his hunger.

the model predictions of 70%-77%. Thus, there was no tendency of devaluing the rejected sticker.

As noted above, the calibrated model predictions are based on the assumption that when a child responds that s/he likes one sticker better than another, then s/he chooses the one s/he likes best in the subsequent choice. Now, as pointed out by Sagarin and Skowronski (2009) in their argument against Chen (2008), there is some literature suggesting that choices are often probabilistic, in the sense that options that are slightly better are chosen only slightly more often than options perceived as slightly less valuable, see e.g. Carroll and De Soete (1991), Estes (1984) and Navarick and Chellsen (1983). If the children take the sticker they like better with probability less than unity, the expected probability for choosing the third sticker in choice 2, with constant preferences is lower than indicated by the model, see arguments in Chen and Risen (2010) and Sagarin and Skowronski (2009). In this case, the experiment cannot be used to detect any carry-over effect. However, as argued by Chen and Risen (2010), the experiments in this literature are typically based on situations where the options differ slightly in some objective terms. For example, a participant may choose a lever giving slightly more food than another lever slightly more often. In such situations it is not clear that the participants expect the difference between the choices to be constant over time. In the present case, the participants are asked a simple question of whether they like one sticker better than the other, and they respond positively to this question. It is then hard to understand why they would not choose the sticker that they like better. On the presumption that there is little noise in the choice of the children after they have stated that they like one sticker better, the result from this part of the experiment provides some evidence against a carry-over effect.

The results where the child responds that s/he likes the stickers Equally well in either of the rounds are more difficult to interpret. Irrespective of whether the Equal answer is in round 1 or 2, the prediction from the calibrated model under constant preferences is that C is chosen in 50%-55% of the cases. However, the empirical ratios are noticeably higher, from 57% to 73%. For the case where the children found the stickers in the first choice equally attractive (row E), and also the subcase where the child subsequently answered L in round 2 (row EL), the higher empirical propensity to choose C in round 2 could be interpreted as indicating a carry-over effect. However, there are two reasons for why one should be reluctant to adopt this conclusion. First, the model predictions under constant preferences are within the confidence intervals for the empirical ratio, so the higher propensity to choose C is not statistically significant. Second, and more importantly, the high propensity to choose C also in the cases where the children answered that they liked the stickers equally much in round 2, makes the interpretation of a possible carry-over effect questionable. The reason is that one would expect a carry-over effect to have an impact on this answer, potentially making a child whose initial preferences would be to answer that s/he likes one sticker (sticker B) better, instead answer that s/he likes the stickers equally well, but not necessarily have an impact on the choice given the answer. The fact that the children show a clear tendency of choosing the novel sticker C also after having said that they like the stickers equally well, strongly suggests that the Equal answer should not be interpreted as always indicating that the child is indifferent between the stickers. Thus, for this part of the experiment, the attempt to elicit a clear indifference did not work as intended,

What can be taken home from these results? Within minimum distance model, assuming that choices are reliable when the children have answered that they like one sticker better than the other, the results provide some evidence against the existence of a carry-over effect when children give this response. In contrast, in the cases when the children have answered that they like the stickers equally well, the point estimates suggest a carry over effect. However, as argued above, this interpretation is questionable. Moreover, it is not clear why two opposing effects should exist after so similar situations, making the carry-over effect even less convincing. Overall, the evidence does not support the existence of a carry over effect, even if the considerable uncertainty implies that it cannot be ruled out. And clearly, the results say little about the possible existence of a carry-over effect after more important or difficult issues than the choices of stickers.

The results also give some reason for concern with how much can be learned from the children's verbal answers: In the experiments, there is in fact very little difference between children's choices depending on the answers. This might suggest that their answer is less informative than the model presumes. On the same account, one could argue that the choices of the children seem fairly robust, being rather close to the simple "no-noise in the choice" model described above, where the predicted propensity for the novel sticker was 2/3. However, also under this interpretation the results do not support the existence of a carry-over effect.

The study has several important implications for future work. The implication with widest applicability is the point raised independently in Chen (2008), Chen and Risen (2010) and a previous version of the present study (Holden, 2008), that when testing for the effect of choices on preferences, one must also control for the fact that choices provide important information about preferences. More specifically, the study also suggests ways of overcoming the problem, which are alternatives to the proposals by Chen and Risen (2010), Risen and Chen (2010) and Egan, Bloom and Santos (2010). The basic idea of the test proposed in the paper is to exploit additional information about the preferences of the children, to better assess whether the choices induce changes in the preferences In the present work, the additional information was supposed to be acquired by means of asking questions. The response indicating indifference did not seem to work, as the subsequent choice suggested that the child was not in fact indifferent. In contrast, the response indicating strict preference seemed to work better, as it clearly will reduce the noise in the subsequent choice. In future work, it would be interesting to explore other means of providing more information about the children's preferences prior to their choices, than to ask questions. One possibility would be to let participants differ with respect to how much information we obtain from them, before their choices. For example, if half of the participants were to make multiple ratings before making a choice, and half make only one rating, one would get more information about the preferences of the former. When the experimenter has more information about the preferences of this group, their choices should also provide less novel information, implying less effect on subsequent choices. This would reduce the choice-information confound, even if it would not entirely eliminate it. However, also with this approach it would seem difficult to ensure that the child is indifferent, and thus to explore the effect of choice in this case.

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Appendix Minimum distance model

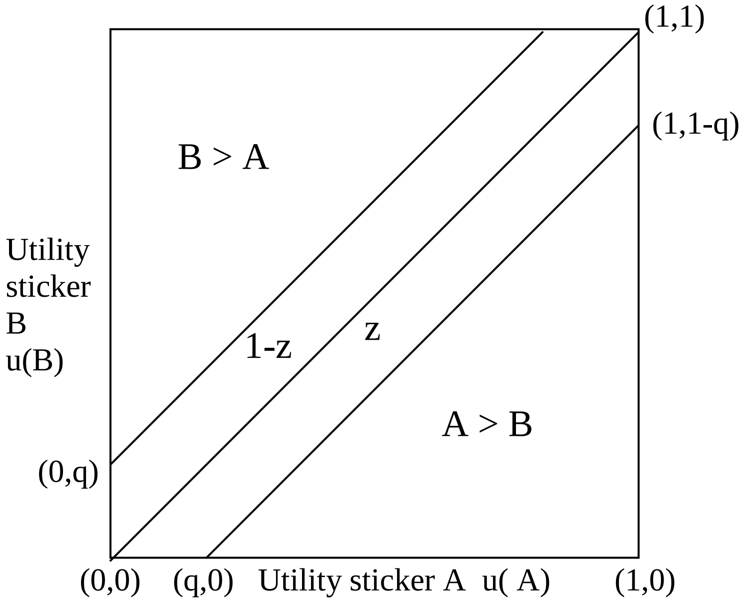
This appendix derives formally which information that can be inferred from the child's actions, based on the minimum distance model with constant preferences. We thus obtain predicted probabilities for the choice in round 2, conditional on the prior actions. Comparing with the actual choices, we can then make statistical inference on whether the preferences have changed.

We assume that the utility or preference of a sticker A, denoted u(A), is uniformly and independently distributed on the interval [0,1]. We consider stickers with the same smiley face ranking, thus this rank is abstracted from. Furthermore, we assume that a minimum distance $q > 0$ is required for the child to be able to say that s/he likes one better than the other. Thus, if $u(A) \geq u(B) + q$, the child will say that s/he likes A better, and in the subsequent choice s/he chooses sticker A. Let $A > B$ denote this event, i.e. $u(A) \geq u(B) + q$. However, if the difference between u(A) and u(B) is less than q, the child says that s/he likes the stickers equally much. In this case we assume that the child chooses the sticker with higher utility with probability $z \geq 0.5$, and the other with probability 1-z.

The preferences for the stickers can be illustrated in the unity-quadrant for u(A), u(B). As the area of the quadrant is equal to unity, and the distribution is uniform, there is a direct correspondence between areas and probability. We observe that $u(A) \geq u(B) + q$ in the area denoted A>B, i.e. the triangle with corners (u(A), u(B)) = (q,0), (1,0) and (1,1-q). For this combination of utilities, the child will say that s/he likes one sticker better, and then choose sticker A.

Figure 1 Preferences and choice of stickers

Figure 1 Preferences and choice of stickers



For utility combinations close to the 45 degree line from (0,0) to (1,1), the difference in utility of the stickers is less than the minimum distance q, and the child responds that s/he likes the stickers equally well (areas labeled z and 1-z). For combinations in the area A>B, we have u(A)≥u(B)+q. Thus, the child says that s/he likes one sticker better and then chooses A.

The probability that this event takes place, which we denote L (Like), is

$P(A>B)=\int_0^{1-q} x\,dx = \Big|_0^{1-q} \frac{1}{2}x^2 = \frac{1}{2}(1-q)^2$. Likewise, the area B > A indicates that the child will say that s/he likes one sticker better, and then choose sticker B. The probability is

$P(B>A)=\frac{1}{2}(1-q)^2$.

If the distance between u(A) and u(B) is less that q, indicated by the areas labeled z and (1-z) in the figure, the child will say that s/he likes the stickers equally well. The probability that this event takes place, which we denote E (Equal), is

$$P(E)=\int_0^q (x+q)\,dx+\int_q^{1-q} 2q\,dx+\int_{1-q}^{1} (1-x+q)\,dx = q(2-q).$$

(As a check, observe that the sum of probabilities of the three possible events is unity: P(A>B)+P(B>A)+P(E)=1.)

Second round, conditional on responding L in round 1

In this section we consider the case when the child says that s/he likes one sticker better in round one, ie the event L. To simplify notation, this is suppressed in the notation below. The child then chooses a sticker, which we conventionally label sticker A. Thus, the outcome corresponds to the area denoted A > B in figure 1, where u(A)≥u(B)+q.

To simplify notation, let x = u(B). Note that the probability that the child in round 2 says that s/he likes one sticker better, and then chooses sticker C, can be written on the following form:

$$P(C > B) = \int_0^{1-q} f(x)P(C > B \mid u(B) = x)dx$$

where f(x) is the conditional density function for u(B), conditional on the event that A>B, ie. that event L has taken place. Observe that we can rule out that x>1-q, because in that case the child could not have answered that s/he liked one sticker better and then chosen sticker A.

We start by deriving f(x). Conditional on u(B)=x, the probability that u(A)≥u(B)+q is

P(u(A)≥u(B)+q|u(B)=x) = P(u(A)≥x+q)	= 1-q-x	for 0≤x≤1-q and
	= 0	for 1-q < x ≤ 1

To derive the density function for x = u(B), conditional on the event that A>B (ie u(A)≥u(B)+q = x+q), which we denote f(x), we must scale by the probability that A>B. We then obtain

$$f(x) = \frac{2}{(1-q)^2}(1-q-x) \quad \textit{for } 0 \le x < 1-q$$
$$= 0 \qquad \textit{for } 1-q \le x \le 1$$

As a check that f(x) is correct, observe that f(x) is zero for x>1-q Furthermore, observe that $\int_0^{1-q} f(x) = \frac{2}{(1-q)^2}\int_0^{1-q}(1-q-x)dx = \frac{2}{(1-q)^2}\frac{1}{2}(1-q)^2 = 1$, ie the integral of the density function is unity.

Now consider the decisions of the child in round 2: The probability that the child says s/he likes one sticker better, and then chooses sticker C, is

$$
\begin{aligned}
P(C > B) &= \int_0^{1-q} f(x)P(C > B \mid u(B) = x)dx \\
&= \frac{2}{(1-q)^2}\int_0^{1-q}(1-q-x)P(u(C) > u(B)+q \mid u(B)=x)dx \\
&= \frac{2}{(1-q)^2}\int_0^{1-q}(1-q-x)^2 dx \\
&= \frac{2}{(1-q)^2}\Big|_0^{1-q}\frac{1}{3}(1-q-x)^3 = \frac{2}{3}(1-q)
\end{aligned}
$$

The probability that the child says s/he likes one sticker better, and then chooses sticker B, is

$$
\begin{aligned}
P(B > C) &= \int_q^{1-q} f(x)P(B > C \mid u(B) = x)dx \\
&= \frac{2}{(1-q)^2}\int_0^{1-q}(1-q-x)P(u(B) > u(C)+q \mid u(B)=x)dx \\
&= \frac{2}{(1-q)^2}\int_q^{1-q}(1-q-x)(x-q)dx \\
&= \frac{2}{(1-q)^2}\Big|_q^{1-q}\left(-(1-q)qx+\frac{1}{2}x^2-\frac{1}{3}x^3\right) \\
&= \frac{2}{(1-q)^2}\left(\frac{1}{6}-q+2q^2-\frac{4}{3}q^3\right)
\end{aligned}
$$

Note that if the minimum distance is large, q = ½, then P(B>C) = 0, i.e. the probability that the child chooses B after responding that s/he likes one sticker better in both rounds is zero. The intuition here is that if q =1/2, a sticker that is said to be less desirable than the other has to be in the lower half of the distribution, and the preferred sticker has to be in the upper half – and clearly u(B) cannot be both above and below ½. On the other hand, if q=0, then P(B>C) = 1/3, i.e. we are back to the case with perfect measurement discussed in the main text.

The probability that a child chooses sticker C, conditional on responding that s/he likes one sticker better than the other in round 2 (as this probability is used for the calculations in Tables 1 and 2, I now include the notation LL, ie the child responds that s/he likes one sticker better in both rounds), is

$$
P(C \mid LL) = \frac{P(C > B)}{P(C > B) + P(B > C)}
$$

The unconditional probability that the child chooses sticker C in round 2 is the sum of the probabilities of two events: (i) that the child says s/he likes one sticker better, and then chooses C; (ii) that the child says that s/he likes both stickers equally well, and then chooses

C. The latter event consists of two cases: that $u(B) < u(C) < u(B) + q$, in which case C is chosen with probability z, and that $u(B)-q<u(C)<u(B)$, so that C is chosen with probability 1-z:

$$P(C) = P(C>B) + zP(u(B)<u(C)<u(B)+q)+(1-z)P(u(B)-q<u(C)<u(B))$$

We have

$$P(u(B) < u(C) < u(B)+q) = \int_0^{1-q} f(x)P(u(B) < u(C) < u(B)+q \mid u(B)=x)dx$$
$$= \frac{2}{(1-q)^2}\int_0^{1-q}(1-q-x)qdx = q$$

(where we use that $P(u(B) < u(C) < u(B)+q \mid u(B)=x) = q \quad for \quad 0 \le x \le 1-q$)

Likewise, we have that

$$P(u(B)-q < u(C) < u(B)) = \int_0^{q} f(x)P(u(B)-q < u(C) < u(B) \mid u(B)=x)\,dx$$
$$= \frac{2}{(1-q)^2}\left(\int_0^{q}(1-q-x)xdx + \int_q^{1-q}(1-q-x)qdx\right)$$
$$= \frac{q}{3(q-1)^2}\left(7q^2-9q+3\right)$$

Here we use that

$$P(u(B)-q < u(C) < u(B) \mid u(B)=x) = x \quad for \quad 0 \le x \le q$$
$$= q \quad for \quad q < x \le 1-q$$

Thus the probability that the child chooses sticker C in round 2 is (for use in Tables 1 and 2, we again include the notation indicating event L in round 1)

$$P(C \mid L) = \frac{-1}{3(q-1)^2}\left(3q-3q^2z+4q^2z+3q^2-5q^3-2\right)$$

Furthermore, the probability that the child chooses sticker C, conditional on responding Equal in round 2, is (for later reference, we again include the notation indicating event LE, ie L in round 1 and E in round 2)

$$P(C\mid LE)=\frac{P(C\cap LE)}{P(LE)}=\frac{zP(u(B)<u(C)<u(B)+q)+(1-z)P(u(B)-q<u(C)<u(B))}{P(u(B)<u(C)<u(B)+q)+P(u(B)-q<u(C)<u(B))}$$

$$=\frac{zq+\frac{(1-z)q}{3(q-1)^2}\left(7q^2-9q+3\right)}{q+\frac{q}{3(q-1)^2}\left(7q^2-9q+3\right)}$$

Second round, conditional on responding E in round 1

In this section we consider the case when the child says that s/he likes both stickers equally well in round one, i.e. event E. To simplify notation, this is suppressed in the notation below.

Again we start by deriving the conditional density for u(B) = x, given the event E and the subsequent choice. To this end, we must first find the probability of E and the choice of A. Observe from Figure 1 that the probability that u(B) < u(A) < u(B)+q , conditional on u(B)=x (corresponding to the area denoted z), is

P(u(B) < u(A) < u(B)+q|u(B)=x)	= q	for $0 \le x \le 1-q$	and
	= 1 –x	for $1-q < x \le 1$.	

With similar reasoning we find (corresponding to the area denoted 1-z)

P(u(B)-q < u(A) < u(B)|u(B)=x)	= x	for $0 \le x \le q$	and
	= q	for $q < x \le 1$.	

As noted above, the child chooses sticker A with probability z if u(B)<u(A)<u(B)+q and with probability (1-z) if u(B)-q<u(A)<u(B). The joint probability of the event E and the child choosing A, conditional on u(B) =x , is

$$P(E\cap choose\ A\mid u(B)=x)\quad \begin{aligned} &= zq+(1-z)x && for\ 0\le x<q\\ &= q && for\ q\le x\le 1-q\\ &= z(1-x)+(1-z)q && for\ 1-q<x\le 1\end{aligned}$$

To derive the joint probability of event E and the child choosing A, we integrate over x:

$$P(E\cap choose\ A)=\int_0^q\left(zq+(1-z)x\right)dx+\int_q^{1-q}q\,dx+\int_{1-q}^1\left(z(1-x)+(1-z)q\right)dx=\frac{2q-q^2}{2}.$$

To find the density function for u(B) = x, conditional on E and the child choosing A, which we denote g(x), we must scale with the probability of the joint event E and choosing A :

$$g(x) = \begin{cases} \dfrac{2}{2q-q^2}(zq+(1-z)x) & \text{for } 0 \le x < q \\ \dfrac{2}{2q-q^2}q & \text{for } q \le x \le 1-q \\ \dfrac{2}{2q-q^2}(z(1-x)+(1-z)q) & \text{for } 1-q < x \le 1 \end{cases}$$

It is straightforward to check that the integral of g(x) from zero to unity is equal to one.

Now consider the decisions of the child in round 2: The probability that the child says s/he likes one sticker better, and then chooses sticker C, is

$$P(C > B) = \int_0^{1-q} g(x)P(C > B \mid u(B) = x)dx$$
$$= \frac{2}{2q-q^2}\int_0^{q}(zq+(1-z)x)(1-x-q)dx + \frac{2}{2q-q^2}\int_q^{1-q} q(1-x-q)dx$$
$$= \frac{1}{6-3q}\left(3qz-4q^2z-9q+7q^2+3\right)$$

The probability that the child says s/he likes one sticker better, and then chooses sticker B, is

$$P(B > C) = \int_q^{1} g(x)P(B > C \mid u(B) = x)dx$$
$$= \frac{2}{2q-q^2}\int_q^{1-q} q(x-q)dx + \frac{2}{2q-q^2}\int_{1-q}^{1}(z(1-x)+(1-z)q)(x-q)dx$$
$$= \frac{1}{6-3q}\left(4q^2z-6q-3qz+3q^2+3\right)$$

The probability that a child chooses sticker C, conditional on responding that s/he likes one sticker better than the other in round 2 (notation for event EL is included), is

$$P(C \mid EL) = \frac{P(C > B)}{P(C > B)+P(B > C)} = \frac{3qz-4q^2z-9q+7q^2+3}{10q^2-15q+6}$$

The unconditional probability that the child chooses sticker C in round 2 is the sum of the probabilities of two events: (i) that the child says s/he likes one sticker better, and then chooses C; (ii) that the child says that s/he likes both stickers equally well, and then chooses C. The latter event consists of two cases: that u(B)< u(C) < u(B) + q , in which case C is chosen with probability z, and that u(B)-q<u(C)<u(B), so that C is chosen with probability 1-z:

P(C) = P(C>B) + zP(u(B)<u(C)<u(B)+q)+(1-z)P(u(B)-q<u(C)<u(B))

We have

$$P(u(B)<u(C)<u(B)+q)=\int_0^1 g(x)P(u(B)<u(C)<u(B)+q\,|\,u(B)=x)dx$$

$$=\frac{2}{2q-q^2}\int_0^q (zq+(1-z)x)qdx+\frac{2}{2q-q^2}\int_q^{1-q} q^2dx+\frac{2}{2q-q^2}\int_{1-q}^1 (zx+(1-z)q)(1-x)dx$$

$$=\frac{2q}{6-3q}\left(qz-3q+3\right)$$

Here we use that

$$P(u(B)<u(C)<u(B)+q\,|\,u(B)=x)=q \quad for \;\; 0\le x\le 1-q$$
$$=1-x \;\; for \;1-\;q<x\le 1$$

Likewise, we have that

$$P(u(B)-q<u(C)<u(B))=\int_0^1 g(x)P(u(B)-q<u(C)<u(B)\,|\,u(B)=x)dx$$

$$=\frac{2}{2q-q^2}\int_0^q (zq+(1-z)x)xdx+\frac{2}{2q-q^2}\int_q^{1-q} q^2dx+\frac{2}{2q-q^2}\int_{1-q}^1 (z(1-x)+(1-z)q)qdx$$

$$=\frac{2q}{6-3q}\left(-qz-2q+3\right)$$

Here we use that

$$P(u(B)-q<u(C)<u(B)\,|\,u(B)=x)=x \quad for \;\; 0\le x\le q$$
$$=q \quad for \;\; q<x\le 1-q$$

Thus (notation indicating event E in round 1 is included)

$$P(C\,|\,E)=\frac{1}{6-3q}\left(4q^2z^2-8q^2z+3q^2+3qz-3q+3\right)$$

Furthermore, (for later reference, we again include the notation indicating event LE)

$$P(C\,|\,EE)=\frac{P(C\cap EE)}{P(EE)}=\frac{zP(u(B)<u(C)<u(B)+q)+(1-z)P(u(B)-q<u(C)<u(B))}{P(u(B)<u(C)<u(B)+q)+P(u(B)-q<u(C)<u(B))}$$

$$=\frac{1}{6-5q}\left(2qz^2-2qz-2q+3\right)$$