How can we increase stability in choices?

The role of confidence

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Master Science Thesis

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Abstract

In this study, we examined how we can increase the consistency by which people make choices. Whether people will choose an item again after making an initial choice is determined by the degree of confidence in the outcome of the initial choice (Folke et al., 2016). To date, studies have only tested the effects of confidence in correlational designs. The current research attempted to experimentally increase confidence in the outcome of choices and thereby stability of choices. We hypothesized confidence could be increased by increasing explicit memory for the choices. In two preregistered lab studies (n = 45 and n = 42) participants decided between same-value choice pairs of food items for consumption. As a manipulation, participants were asked to recall the outcomes of their choices for some of the pairs. This was done to increase explicit memory for the outcome of the choice. Afterwards, they rated confidence in the outcome of their choices. Next, they received each choice pair again four times to measure choice stability. The memory manipulation failed to work in the first experiment, but in the second experiment, this manipulation was successful. Results of the second experiment indicated that participants were more confident in choices they had recalled previously and were also more likely to repeat these choices. This effect of choice recall on stability was mediated by choice confidence. These findings signify that choice confidence is an important determinant of choice stability, and that an intervention focused on establishing strong memory representations for initial choices can increase choice stability via choice confidence.

How can we increase stability in choices? The role of confidence.

We make many choices every day. Some seem set in stone, while others are very changeable. The stability of a choice is an important factor in sustainable behavioural change. To achieve sustainable change, it is not only necessary to induce a change in choice, but also to stabilize the new choice into consistent behaviour. This makes choice stability an interesting topic for research, as many societal problems can be resolved by adopting different behaviour (Thaler & Sunstein, 2008). While successful interventions have been found to change an initial choice (e.g. Dorresteijn, van der Graaf, Zheng, Spiering, & Visseren, 2013; Kroese, Marchiori & de Ridder, 2015), creating stability in that choice is more difficult (e.g. de Wit et al., in press). Therefore, it is interesting to explore what factors play a role in creating choice stability.

A recent study by Folke, Jacobsen, Fleming and De Martino (2016) investigated the idea that confidence in the outcome of choice could be one of the factors playing a role in creating choice stability. In this study participants made binary choices between different-value food items, of which one choice was paid out at the end. After each choice, participants rated their explicit confidence in the outcome of the choice, while the frequency of gaze shift between the items was used as a measure of implicit choice confidence. The choices were then presented once more and whether the participant changed his mind was operationalized as choice stability. Lower explicit choice confidence was associated with a lower stability, but implicit choice confidence did not predict a change of mind. These results persisted after controlling for pre-choice value difference of the items and reaction times. Thus, it was demonstrated that explicit confidence in the outcome of a choice is a factor of choice stability.

Increasing confidence in the outcome of a choice, then, could be a promising way to increasing choice stability. This possible causal link has not been researched by Folke et al. (2016). While there are no known studies exploring how to increase confidence in a choice, there are studies that have tried to increase confidence and similar constructs in the field of attitudes and cognitions. From these studies, we will discuss the effect of accessibility on commitment to an attitude, the effect of ease of retrieval on confidence, and the effect of item familiarity on choice confidence, as these effects give relevant insights in possible ways to create choice confidence.

Firstly, the study by Holland, Verplanken and Van Knippenberg (2003), attempted to increase attitude certainty and decrease perceived likelihood to change an attitude. While this research called these two factors indicators of attitude commitment, we argue that these items are representative for confidence in an attitude. In the study, participants ascribed one of two words to an object (e.g. “positive” or “negative” to “European Unification”), and did this for two objects either one time or six times. Explicit attitude measures were taken, as well as reaction times for how fast participants could indicate whether the object was positive or negative to them. These reaction times were measured to create an attitude accessibility score. Holland et al. (2003) found a link between accessibility of the attitude and increased confidence to that attitude. Additionally, the repeated expression of the attitude increased the attitude confidence, mediated through attitude accessibility. Summarizing, the study found that it was possible to increase attitude confidence by repeated expression, because the repeated expression increased attitude accessibility, which in turn increased confidence in the attitude.

Secondly, a study on confidence was conducted in the domain of cognition (Kelley and Lindsay, 1993) to find whether ease of memory retrieval increases confidence. In this study participants answered knowledge questions and then rated their confidence in the answers. Before the quiz, participants read a list of words that were semantically similar to some correct and incorrect answers to the questions. The speed at which an answer comes to mind was measured as the time until an answer was given, called ease of retrieval, where high ease of retrieval meant low reaction times and vice versa. After exposure to the list, ease of retrieval increased for both the correct and incorrect responses that were semantically similar to the list. More importantly, participants reported being more confident in both correct and incorrect responses they retrieved more easily, indicating a causal role of ease of retrieval in creating explicit choice confidence.

Thirdly, the results of a food choice experiment by Fleming and De Martino (2014) indicate that item familiarity is a predictor of explicit choice confidence. In this study, participants made choices between food items, rated for each choice their confidence that they had made the right decision, and then had to make the same choice again later. The study then tried to identify predictors for choice confidence, and found two: pre-choice value difference and post-choice item familiarity. Just like Folke et al. (2016), this study also found low explicit choice confidence to be associated with a later change of mind.

Lastly, in the previously discussed study by Holland et al. (2003) repetition was tied to increased attitude confidence, but this study did not include a stability measure to make the link from repetition to stability. A study done by Riefer, Prior, Pavey and Love (2017) does tie repetition directly to choice stability. In a large consumer sample of supermarket data, it was found that the more people had repeated their choice for a product, the less likely they were

to explore different products: they became more stable in their choice. This was done by sending customers coupons that promoted a different choice. The longer a consumer was on a streak of choosing the same product, the less likely they were to redeem this coupon, so the more stable in their choice they were. It is possible that this increase in choice stability due to choice repetition was mediated by consumers' confidence in the outcome of their choice. However, choice confidence was not measured in this study, so it could not be investigated whether this was actually the case. Combined, the studies of Holland et al. (2003) and Riefer et al. (2017) hint towards an effect of repetition on confidence and stability.

In summary, different studies have discovered several constructs to be linked to confidence and choice stability. The factors accessibility, ease of retrieval, item familiarity and repetition all play a role. However, no successful intervention has been designed as of yet to increase confidence in a choice. Combining the findings in the aforementioned studies, we propose an intervention to increase explicit confidence in the outcome of a choice. We suggest that an intervention that increases explicit memory can lead to increased confidence. This intervention takes the form of facilitating the active recall of a choice: participants will be asked to remember some decisions, and recall what they chose later. We deem this intervention suitable for increasing explicit memory: the more something is processed, the better it is memorized (Craig & Tulving, 1975). Additionally, active recall is of great importance in learning and long term memory (Karpicke & Roediger, 2008), and is still deemed important and effective for learning (e.g. Augustin, 2014; Inouye, Bae & Hayes, 2017).

We hypothesize that the aforementioned effects are all engaged in an intervention that improves explicit memory through facilitating active recall. Better explicit memory of a choice outcome through active recall could impact all factors previously discussed: retrieving a memory improves its accessibility in the future (Karpicke, 2016), a better memory for an item increases its familiarity (Ryals, Cleary, & Seger, 2013), ease of retrieval of an item can be increased by exposure to that item (Kelley & Lindsay, 1993) and lastly, by definition, the active recall training facilitates repetition of the choice.

The current research builds on the study done by Folke et al. (2016) but instead of testing the relation between confidence and stability as correlational, this is tested experimentally, to find out whether explicit choice confidence can cause choice stability. Additionally, it is investigated whether facilitating choice recall can be used as a suitable manipulation to increase choice confidence, and whether this manipulation can indeed increase choice stability, mediated through an increase in confidence. This leads to the following overview of the theoretical model tested in this study, as seen in Figure 1:

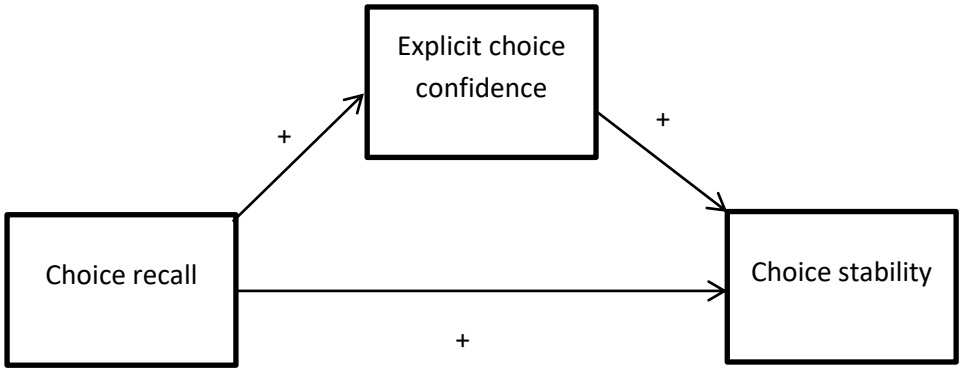

Figure 1. A visual overview of the theoretical model.

In addition to testing this theoretical model, this research will explore the role of value in choice confidence and choice stability, as value has an important role in choice making. It has been found that a large value difference between options leads to an easier choice and therefore more confidence (De Martino, Fleming, Garrett & Dolan, 2013; Folke et al., 2016).

In the study of Folke et al. (2016) the effect of value difference between choice options was accounted for in the analysis. For a cleaner measurement of the effect of value, choice pairs used in this study are a priori same value. This is done to prevent confidence simply being inferred from value difference, a process suggested by Fleming & De Martino (2014). Additionally, a post-choice value difference measure is added to this study, because the value of an item can change by choosing or not choosing it (Bem, 1972; Ariely & Norton, 2008). No hypotheses are formulated for the effect of value, but because of the ties value has with choice confidence (De Martino et al., 2013; Fleming & De Martino, 2014; Folke et al., 2016) and choice stability, it is investigated in an exploratory fashion.

Experiment 1

Method

Overview. To test the hypotheses, a within-subject experimental setup was designed. Participants were asked to rate images of food items based on their liking of the item. This serves as pre-choice value measurement. These rankings were used to create image pairs of equal value for each participant. For each pair, participants then made a choice between images. A within-subject factor is the recall intervention: choice pairs were randomly divided between the Control condition and the Recall condition. The participant was asked to remember and recall their choices for the choice pairs in the Recall condition, but not for those in the Control condition. The goal was to improve the explicit memory for choices in the Recall condition, compared to those in the Control condition. Explicit choice confidence was measured after the choice task, followed by another value rating task as an exploratory measure of post-choice value. Choice stability was then measured by presenting all choice pairs again four times and checking if they corresponded with the initial choice made by the participant. Lastly, a memory test was conducted, in which participants were asked to remember and re-do their initial choice. This served as a manipulation check for the recall intervention, which is supposed to improve memory. At the end of the experiment, participants received a snack sampled from a subset of choices they made during the experiment from three predetermined Filler choice pairs. Participants were informed about this before the task, which made their choices have meaningful consequences. This allows us to investigate the choices as real instead of hypothetical. An overview of the experiment can be found in Table 1.

Table 1
Overview of Experiment 1.

Time	Task	Measurement
T0	Pre-choice value measurement	Pre-choice value
T1	Initial choice task	Initial choices & memory manipulation
T2	Choice confidence task	Explicit choice confidence
T3	Post-choice value measurement	Post-choice value
T4	Stability task	Choice stability
T5	Memory task	Correctness of memory of initial choice outcome

Design. To test the theoretical model, a within-subject experimental setup was created. The Independent variables are: condition (Recall or Control), explicit choice confidence, pre-choice item value and post-choice item value. The main dependent variable is choice stability, and correctness of memory for each initial choice was measured as a validation check.

Participants. A total of 45 participants were recruited at the Radboud University using the research institutes' participant pool. This total was based on a power analysis using PANGEA (Westfall, 2017), aiming for a power of 0.8, taking participant ID as random factor and condition as fixed factor. An average effect size in social psychology, Cohen's *d* = 0.45, (Richard, Bond and Stookes-Zota, 2003) was taken as reference point due to the lack of power estimates in the relevant literature, resulting in a sample size of 30. However, because of the uncertainty of the effect size, we aimed for a more conservative goal, based on the median effect size of *d* = 0.36 (Richard, Bond and Stookes-Zota, 2003), which is a total of 45 participants. Participants were reimbursed with either partial credit or cheques for participating in the experiment. The experiment spanned about 30 minutes in total.

Participants filled out a consent form before participation. Participants with food restrictions, such as diet, allergies, or ideology, were excluded from participation.

Materials. In the task, 66 pictures of unhealthy snacks were used. These pictures were taken from the study done by Veling et al. (2017). These pictures consisted of the snack in packaging, with a part of the product in front of it, photographed with a black background. An example can be seen in Figure 2. The snacks were all non-perishable and available in the Netherlands. Of the 66 pictures, 6 were selected as Filler snacks (Mars, Snickers, Kanjer Stroopwafels, Milka Oreo, Lay's naturel chips and Kinder Bueno). At the end of the experiment, every participant received one of these snacks. Which snack they received was based on their choices for the Filler trials during the task.

Figure 2. An example of a stimulus used in Experiment 1 and 2.

Procedure. Participants were welcomed in the lab, seated and then instructed about the experiment, following a script, which can be found in appendix A. Before they started, participants filled in the demographic measurements age and gender. The experiment consisted of several tasks. The experimenter was present for the practice trials preceding the initial choice task and the explicit choice confidence task to ensure that the participant understood the task.

Pre-choice value rating task. Participants were presented with a total of 66 pictures of different snacks one by one on screen and were asked how much they would like to receive that snack at the end of the experiment, indicating this on a slider scale from

"not at all" to "very much". This rating was converted to a score of 0 to 100, creating the variable pre-choice value. This variable was used to create the choice pairs for the rest of the experiment.

Choice pair creation. The 60 target pictures were ranked based on this value measurement indicated by the participant. The top four and bottom four snacks in this ranking were paired to create four Validation pairs, consisting of one extremely high value item and the other extremely low. This was done for validation purposes: participants doing the task as intended would choose almost exclusively the high-valued item. The rest of the snacks were paired based on their ranking to create 26 approximately same value pairs (so the 5th highest rated snack was paired with the 6th, the 7th with the 8th, etc.). These 26 pairs were alternately assigned to the experimental and non-experimental condition. This alternation was counterbalanced between participants. The Filler items were paired the same way for every participant: their value rating was not used. This procedure resulted in a total of 33 pairs: 13 in the Control condition, 13 in the Recall condition, 4 in the Validation condition and 3 in the Filler condition. A visual overview of choice pair creation can be found in Figure 3.

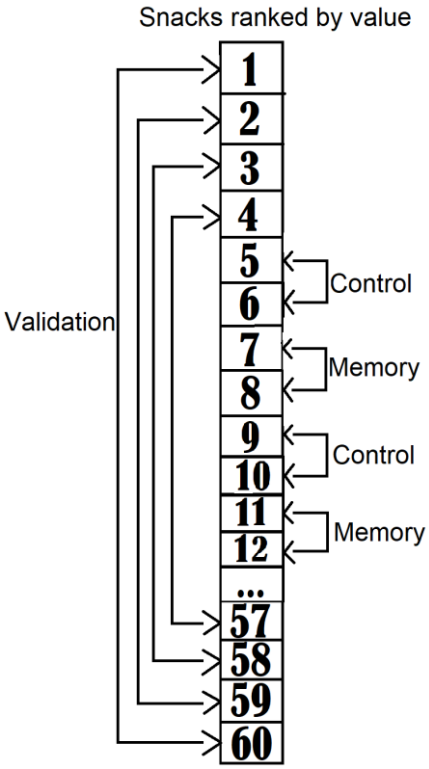

Figure 3. Overview of the pairing procedure in Experiment 1

Initial choice task. After rating pre-choice value, participants were presented with the initial choice task. In this task they were shown the choice pairs one by one and asked

which of the two options they would like to receive at the end of the experiment. Before each trial, a fixation cross was presented for one second. Position (left-right) of the two snacks was randomly determined and stayed fixed throughout the experiment. The trial sequence was counterbalanced between participants, for some starting with a Control pair and for some with a Recall pair. This task was used as the manipulation, creating two conditions, but also as the basis for the choice stability measure later.

A choice trial consisted of two snack images appearing next to each other with the instruction “Please choose the option you would like to receive at the end of the experiment”. Participants could indicate their selection by clicking their preferred option. One of these chosen items would be paid out to the participant at the end. After selection, an outline appeared around the selected option and was shown for one second before going to the next trial. For the Control, Validation and Filler choice pairs, this outline was blue. When the choice pair was a Recall pair, the outline was purple, as seen in Figure 4. This indicated to the participant that they had to memorize this choice, because they would have to remember in later Recall trials which of the items they preferred for this trial. Choice pairs in the Recall condition are associated with two Recall trials, namely two and four trials after the initial choice trial for that pair. During these Recall trials participants were asked to recall and repeat the decision they made earlier. Visuals for this procedure can be found in Figure 5. Feedback was given if their answer was incorrect, and if so, the trial was presented one extra time at the end of the initial choice task block, until answered correctly.

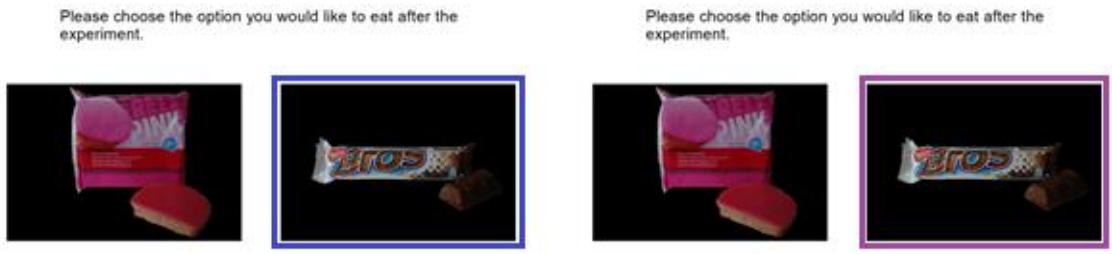

Figure 4. After making a choice, the coloured border signaled to the participant that the trial would not return (blue; the Control, Validation and Filler conditions) or would come back later (purple; the Recall condition).

Figure 5. Initial choice trial of a Recall choice pair and the subsequent Recall trial.

Explicit choice confidence task. Next, confidence in each choice was measured after the choice task. Participants were presented with all choice pairs, with the previously chosen item outlined in yellow, and were asked how confident they were in this choice (based on the method used by Folke et al., 2016). Participants could answer on a slider scale from "not at all" to "very much". This task was used to measure explicit choice confidence, resulting in a result ranging from 0 to 100. An illustration of this task can be found in Figure 6.

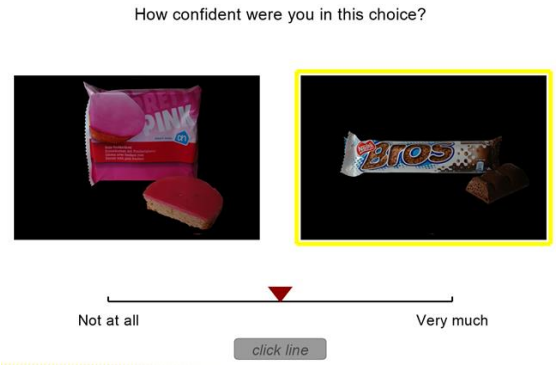

Figure 6. Explicit choice confidence task.

Post-choice value rating task. After the explicit choice confidence task, the post-choice value task started. This task was identical to the pre-choice value task and was intended to measure the value of each item after the decision, which allows us to look at increases or decreases in value per item. At the end of this task, a break of 5 minutes started, to reduce possible exhaustion effects. The experimenter checked up on the participants during the break.

Choice stability task. After the break, the choice stability task started, which is the measure of the main outcome variable. Participants are presented with more choice pairs and asked to make a decision based on what they want to receive at the end of the experiment. It was stressed to the participants to choose what they wanted to eat, irrespective of their previous decisions. In this part of the experiment, four trial blocks with all Validation, Control and Recall choice pairs were created, shuffled and then presented. The Filler choice pairs are presented between the blocks, to avoid the possibility of the same choice being presented last in one block, and then immediately afterwards in the next block. This procedure lead to a total of 129 choices made in this task: four times the Validation pairs (total of 16), four times the Recall pairs (total of 52), four times the Control pairs (total of 52) and three times the Filler trials (total of 9). This task is used to create the dependent variable choice stability. This stability score is created by checking consistency of the decision with the initial choice made for that choice pair (0-1).

Memory task. All choice pairs are presented again in a memory task, similar to the manner in which memory trials are presented in the initial choice task. Participants were asked for every choice pair which one they had chosen in the initial choice task: “Please choose the option you chose in the first task”. Scores were created based on

correspondence with the initial choice task (0-1). This functions as a manipulation check to see if the manipulation increased memory. At the end of this task, a snack was randomly drawn from the chosen items from Filler choice trials, and this snack was shown on screen.

After the computer task, the participant was debriefed and received the selected snack and partial credit or cheque. During this debriefing, participants were asked to recall the instructions of the memory task. Namely, whether they were supposed to recall their choices made before or after the break. This was done to avoid inclusion of this data from participants that had misinterpreted the task.

Data analysis. The data were analyzed using a mixed effects model approach in the statistical program R (R Core Team, 2016), using the lme4 package (Bates, Maechler, Bolke & Walker, 2015), with participant as a random factor. One model was set up per hypothesis. To determine p-values, the KRmodcomp function of the package pbkrtest (Halekoh & Højsgaard, 2014) was used, which performs conditional F tests with degrees of freedom based on the Kenward-Roger approximation (Luke, 2017). In case this was not compatible with the model, the PBmodcomp function of the package pbkrtest (Halekoh & Højsgaard, 2014) was used instead, which performs model comparison of nested models using parametric bootstrap methods. Variables were centered and scaled when necessary. To optimize the random structure, the suggestions of Barr, Levy, Scheepers and Tily (2013) were used as a guideline. Had the models failed to converge, the corresponding ANOVAs would have been used instead.

In order to test the effect of condition on confidence, a mixed model approach was used, with condition as independent variable and confidence as dependent variable. Choice pair (describing any unique combination of two pictures) and participant ID were used as

random effects with condition added to them as a random slope. This model was preregistered: lmer(confidence ~ condition (1 + condition | participantID) + (1+ condition | choice pair)).

To replicate the effect of confidence on stability as found in the research done by Folke et al. (2016), a mixed model approach with confidence as independent variable and stability as dependent variable was used. Participant ID and choice pair were used as random factor, with condition as random slope. The resulting model looks as follows and was preregistered: glmer(stability ~ condition (1+condition | participantID) + (1+condition | choice pair)).

Some deviations from the preregistration were made regarding these two models based on the data. Because of the way choice pairs were created, it was a priori possible that each created choice pair could be found in both conditions. For example, the choice pair M&M's and Bounty could be in the Recall condition for one participant, but in the Control condition for another participant. This possibility was accounted for in the preregistered models by including condition as a random slope for choice pair. However, not all choice pairs could be found in both conditions, while this is a prerequisite for inclusion in the model. Because of this, condition could no longer reliably be included as random slope for choice pair and was taken out of both models.

Also, in the model with confidence as predictor, the random effect of choice pair was taken out completely. This because variance within the choice pair could not exist within participants: a choice pair has only one confidence score per participant. The between-subject variance of a choice pair is already accounted for in the model by the inclusion of participant as random factor. As such, the inclusion of choice pair as random factor is not

needed. These changes combined resulted in the final first model looking as follows: lmer(confidence ~ condition (1 + condition | participantID)) and the second model looking as follows: glmer(stability ~ condition (1+condition | participantID) + (1 | choice pair)).

The effect of confidence on stability mirrors the study done by Folke et al. (2016). This was tested using a mixed-model approach, with condition as independent variable and stability as a binary factor as the dependent variable. Participant ID and choice pair were used as random factors, and condition was added to participant ID as a random slope. This model looks as follows: glmer(stability ~ confidence (1+confidence | participantID) + (1 | choice pair).

Should these three hypotheses be confirmed, a model will be used to test for possible mediation of confidence in the relationship between condition and stability. To test this mediation, the joint significant approach was deemed to be the best approach for when full mediation is not expected (Fritz and MacKinnon, 2007; Hayes and Scharkow, 2013). Considering the role of value found in the literature and in Experiment 1, full mediation is not expected. Significance testing on possible found effects will be conducted through Sobel testing (Sobel, 1982). For the analysis, the effect of condition on stability in the second model will be compared with the same effect in a similar model with confidence added as fixed effect and random intercept, looking as follows: glmer(stable ~ condition + confidence + (1 + condition + confidence | subjectID) + (1 + condition + confidence | PairName)).

Finally, the manipulation check tests whether correct memory goes up in the Memory condition, which is the intended effect of the manipulation. Correct memory was taken as binary dependent variable, while condition was used as independent variable. This model looks as follows: glmer(correctMemory ~ condition (1 + condition | participantID).

No a priori exclusion criteria were formulated, so all participants who completed the experiment are included in the main analyses. That is because the current procedure has not been used before. Post hoc exclusions were applied where we thought this appropriate depending on the data. Specifically, participants that misinterpreted the memory task were excluded from tests involving the results from that task, but were otherwise included.

Results

In total, 45 participants (75.5% female; M_{age} = 23.82, age range 18-61) performed the experiment. All participants completed the practice trials successfully and indicated their understanding of the tasks. Descriptive information of the main variables of the experiment can be found in Table 2.

Table 2.
Descriptives of the main variables in Experiment 1.

Variable	Both conditions *Mean* (SD)	Control condition *Mean* (SD)	Recall condition *Mean* (SD)
Pre-choice value	50.04 (27.28)	51.59 (21.29)	48.49 (27.34)
Post-choice value	48.25 (25.58)	49.03 (25.31)	47.48 (25.83)
Confidence	66.18 (26.07)	66.52 (25.78)	65.84 (26.36)
Pre-choice value difference	0.28 (2.80)	0.24 (3.10)	0.33 (2.47)
Post-choice value difference	15.47 (20.60)	15.37 (20.04)	15.56 (21.14)
	Percentage		
Memory accuracy for initial choice	92.6%	91.0%	94.2%
Choices consistent with initial choice	89.0%	91.9%	95.2%

In Table 3, a stability sum score per choice pair is created for each choice pair in the stability task. As all pairs were repeated four times in this task, a maximum score of 4 means that the participant was consistent with their initial choice for this choice pair all four times,

while 0 means that for this choice pair, the participant never made the same choice they made initially.

Table 3.
Frequency table of the stability score (0 - 4) of each choice pair in Experiment 1. The score indicates how many choices in the stability task correspond with its initial choice.

Choices consistent with initial choice per pair	Total number of pairs	Total number of pairs in Control condition	Total number of pairs in Recall condition
0	76 (6.5%)	48 (8.2%)	28 (4.8%)
1	30 (2.6%)	16 (2.7%)	14 (2.4%)
2	28 (2.4%)	18 (3.1%)	10 (1.7%)
3	63 (5.4%)	38 (6.5%)	25 (4.3%)
4	973 (83.2%)	465 (79.5%)	508 (86.8%)

Manipulation check. The Validation choice pairs, which consisted of one extremely high and one extremely low rated food item, were investigated to find out whether participants did the task as intended. Of the 360 choices made, 358 choices were for the high value item, and only 2 for the low-value item. This indicates that participants took the task seriously and there was no reason for post hoc exclusion of participants on this basis.

It was then investigated whether the Recall condition in the initial choice task was understood correctly. Only 1.0% of choices were recalled incorrectly during the initial choice task, indicating a proper understanding of the task, and that the recall training was not too difficult.

To check whether the attempted increase in memory for pairs in the Recall condition was successful, a mixed model approach was used as described in the method section. Participants were excluded from this analysis if they had failed to indicate the correct

instructions of the memory task at the end of the experiment. Of the 45 participants, 41 had recalled the purpose of the memory task correctly at the experiment's end. Correct recall did not differ significantly between conditions: (Estimate = -0.21, SE = 0.18, χ^2 (1) = 1.44, p = .23), meaning that the aimed effect of the repetition was not achieved. Correct recall was very high in both the Recall condition (94.2%) as the Control condition (91.0%).

Additionally, it was investigated whether the attempt at creating same value couples succeeded. The average difference between two paired target items was 0.28 (*SD* = 2.80) which indicates that the creation of approximately same-value pairs was successful. This pre-choice difference was not different between the Recall (*M* = 0.33, *SD* = 2.47) and the Control condition (*M* = 0.24, *SD* = 3.10): Estimate = -0.05, SE = 0.62, F (1, 44.56) < 1, p = 0.61.

Effect of condition on confidence. Condition had no significant effect on confidence: Estimate = 0.34, SE = 0.64, F (1, 44.01) < 1, p = .60, with pairs in the Recall condition (*M* = 65.84, *SD* = 26.36) not scoring higher or lower than pairs in the Control condition (*M* = 66.52, *SD* = 25.78)

Effect of confidence on stability. Explicit confidence in a choice positively predicts later stability in that choice, (Estimate = .05, SE = 0.01, χ^2 (1) = 33, p < .001), see Figure 7. Just as in the research of Folke et al. (2016), the higher the confidence, the more likely it is to be associated with a stable choice.

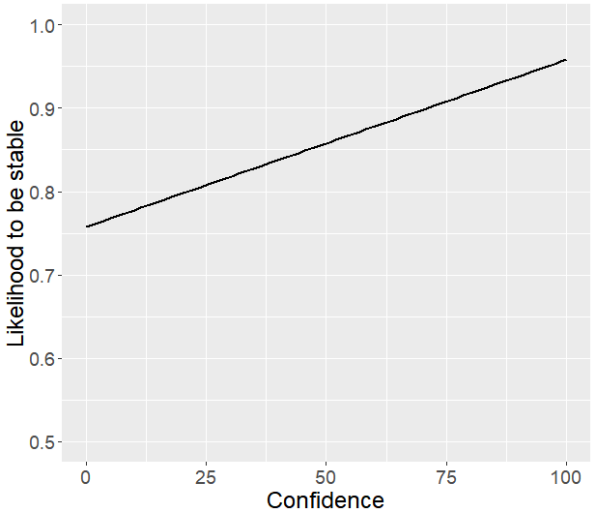

Figure 7. Regression line of the effect of confidence on the likelihood to remain stable.

Effect of condition on stability. A possible direct effect of condition on stability was investigated. Conditions differed significantly in stability (Estimate = -0.50, SE = 0.31, χ^2 (1) = 5.91, p = 0.02), with choices in the Recall condition being more often stable (91.5%) than those in the Control condition (86.5%).

The effect of value. In an exploratory analysis, the effects of value difference were investigated. To do this, the item value shift was created. The item value shift is simply the difference between the pre-choice value of item A and the post-choice value of item A. An example is provided in Table 4.

Table 4.
An overview of the value measurements and their creation.

	Pre-choice	*Post-choice*	*Item value shift (difference pre – post)*
Value item A	20	27	7
Value item B	23	18	-5
Value difference	3	9	

First, using a paired sample t-test, the item value shift for chosen items was compared to that of not chosen items, to find whether choosing an item changes its value. This difference was significant (t (44) = 7.10, $p < .001$) with chosen items going up in value (M = 5.80, SD = 17.15) while not chosen items decreased in value (M = -9.38, SD = 17.13). This was further investigated using a mixed model approach, using chosen or not chosen item value shift as dependent variable, condition as fixed effect and random slope, and participant ID as random intercept. No differences between not chosen items were found based on condition (Estimate = -0.75, SE = 0.49, F (1, 44.95) = 2.33, p = .13). Interestingly, condition has a significant effect on the value increase of chosen items, with items in the Recall condition increasing more in value on average (M = 6.60, SD = 17.72) than items in the

Control condition (*M* = 5.00, *SD* = 16.54), Estimate = -0.50, SE = 0.31, F (1, 44.73) = 5.71, *p* = .02).

Condition had no effect on the post-choice value difference between the items (Estimate = -0.09, SE = 0.65, F (1, 44.15) < 1, *p* = .88) meaning that the value difference after the choice does not differ between the Recall (M = 15.56, SD = 21.14) and the Control condition (M = 15.37, SD = 20.03).

The post-choice value difference correlates with choice confidence: F (1, 50.23) = 98.02, *p* < .001. The higher the post-value difference, the higher the confidence (Estimate = 7.66, SE = 0.77). Additionally, the post-choice value difference also predicts later stability: χ^2 (1) = 54.99, *p* < .001. The higher the post-choice value difference, the more likely a choice is to be stable (Estimate = 1.95, SE = 0.31).

Discussion Experiment 1

The goal of Experiment 1 was to discover whether confidence in the outcome of choices, and subsequent choice stability, can be increased by increasing explicit memory for choices. To see whether the manipulation of explicit memory was successful, a manipulation check was done, which indicated that no difference in explicit memory was created between conditions. The task seems otherwise validated. Choice stability and confidence in the choice is strongly correlated, as expected by the results of Folke et al. (2016). The recall task was performed correctly with few mistakes. On validation trials, people chose high over low value items, suggesting the choice tasks and value measurements were valid. The counterbalanced distribution of choice pairs was successful, as no difference between conditions in pre-choice value difference existed.

Although the manipulation check gave no reason to assume any difference between those conditions, there was an effect of condition on choice stability. This gave reason to look more closely to the choice confidence and memory measure, as it may be that the effect of condition on choice confidence was present, but was not visible due to measurement issues. We identified several issues that can explain this unexpected finding.

First, the baseline correct recall of the initial choice was very high, as 91% of Control choices were recalled correctly. We suspect that the baseline memory was too high to allow for variance. As our Recall manipulation attempted to increase explicit memory, this left very little room for improvement, as it is more difficult to detect the improvement of an already very high score. This may be caused by the task being too easy, with a total of only 33 distinctly different choices.

Second, in hindsight, the way confidence was measured may have interfered with the theorized process of confidence creation and the intended memory training of the Recall intervention. We theorized previously that confidence is interfered from its accessibility from memory. However, during the explicit choice confidence task, the choice was presented with the chosen option outlined, to prevent ambiguity. This manner of presentation interferes with the process of inferring confidence from memory accessibility, as during this task all outcomes were equally accessible regardless of previous manipulations of explicit memory. This makes accessibility in memory irrelevant for generating confidence, because the correct choice is shown to the participant for all choices, removing the need to access memory at all. This could mean that the confidence in Experiment 1 was measured without the hypothesized boost provided by the Recall intervention, as there was no need for memory access during the confidence rating. However, when participants were later

presented with the stability task, accessibility could still play a role in driving choices via confidence, as in that task (and unlike during the confidence measurement) the previous initially chosen outcome was not indicated. When this accessibility did differ between conditions because of the Recall training, participants may have been more confident in choices in the Recall condition, which in turn made these choices more stable, but due to the weakness in the confidence task this was not reflected in the confidence measurement.

Third, the presentation of the initial choice during the confidence measurement serves as a form of memory training for choices in both conditions, something to be avoided for the Control condition. It is possible that this has influenced the memory task later on, clouding the difference between the two conditions. These issues are addressed in Experiment 2.

Experiment 2

Method

Overview. To correct for the weaknesses of the design of Experiment 1, several changes were made to be able to answer all research questions. These changes are described below. The rest of the method remained the same. 45 participants were recruited for the experiment. An overview of the experiment can be found in Table 5.

Table 5.
Overview of Experiment 2.

Time	*Task*	*Measurement*
T0	Pre-choice value measurement	Pre-choice value
T1	Initial choice task	Initial choices and condition manipulation
T2	Choice confidence task	Correctness of memory, recall time, and explicit choice confidence
T3	Post-choice value measurement	Post-choice value
T4	Stability task	Choice stability

Changes. The problems with Experiment 1 were twofold. First, the design of the explicit confidence task interfered with the manipulation of memory and with the hypothesized effect of accessibility on confidence creation. Second, memory was very high in both conditions, causing a possible ceiling effect.

To solve the first issue, a new explicit choice confidence task was designed. The new task serves as measurement of explicit confidence in the outcome of the choice and of correct memory. To avoid possible confusion, it was made explicit that confidence in the outcome of the choice was asked, as opposed to confidence in the correctness of their memory. This was made explicit in the task instructions, and the experimenter explicitly mentioned this during the practice trials. Additionally, a measurement of reaction time was

added to the task. Fast responses can be a measure of accessibility in memory, as suggested by Holland et al. (2003) and Kelley and Lindsay (1993). As we believe this accessibility to be an indication for confidence, we added this measure in the second experiment.

The new explicit choice confidence task is as follows: participants are presented with a choice pair and asked which one they chose in the previous task. After selecting an option, a Confirm button appears after a second. A change of mind is still possible before pressing the Confirm button. The time from presentation until confirmation was measured as recall time. This recall time is taken as an exploratory measure for the accessibility for the memory of the choice. When the memory is confirmed, the confidence task as described in Experiment 1 is presented, with a yellow outline around the memorized option. The question in the task was changed to "To what extent are you confident in your preference for the chosen item over the other item?" This task was preceded by practice trials during which the experimenter was present to make sure all participants understood the task correctly. This new task circumvents the interference on accessibility and the memory manipulation that the task in Experiment 1 had. A visualisation of this task can be found in Figure 8. Because of the memory aspect added to this task, the memory task at the end of the experiment was removed.

Figure 8. Improved explicit choice confidence task. Participants are presented with the left image first. Once they have made their selection, a confirm button appears after a second. Upon pressing, the confidence rating starts, as seen on the right.

To reduce the ceiling effect of correct memory, we attempted to make the task more difficult. We did this in several ways. Firstly, the position of the snacks (left-right) was randomized throughout the experiment, not randomly determined at the start and then fixed. Secondly, the procedure for pair making was changed to increase the amount and difficulty of the trials in the experiment, to allow for more variance in correctness of memory. 68 pictures of snack items are presented to the participant, of which 6 Filler items. These filler items were the same as in Experiment 1, paired in the same way for every participant. They were used to determine the pay-out at the end. The remaining 62 items were then ranked based on the pre-choice value measure. Four Validation pairs were created from the top and bottom four, as in Experiment 1. Then, groups of three items of approximately same value are created and alternately assigned to either the Recall or Control condition. These triples were then formed into three approximately same-value pairs. For example, the items 5, 6, 7, 8, 9, and 10 would first be grouped into same-value groups 5-6-7 and 8-9-10. 5-6-7 is then assigned to the Control condition, while 8-9-10 is assigned to Recall (or vice versa; this was counterbalanced between participants). Lastly, the groups are split up to create pairs: 5-6, 6-7 and 5-7 in the Control condition, and 8-9, 9-10, and 8-10 in the Recall condition. An overview of the new procedure can be found in Figure 9. This procedure both increases the number of unique pairs and thus the difficulty of recall, because every snack item is featured twice.

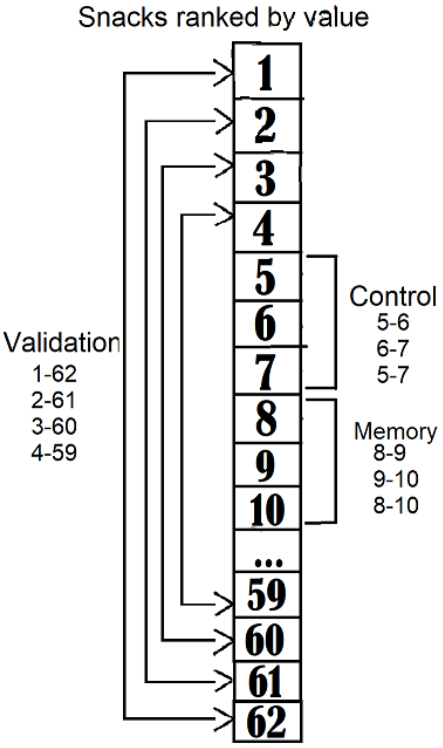

Figure 9. Overview of the pairing procedure in Experiment 2

Using this method led to 4 Validation pairs, 3 Filler pairs, 27 Recall pairs and 27 Control pairs, totalling 61 initial choice pairs per participant. For the stability task, this meant four times four Validation pairs (totalling 16), four times 27 Recall pairs (totalling 108), four times 27 Control pairs (totalling 108) and in between the blocks three times three Filler trials (totalling 9). This leads to a total of 241 choice pairs in the stability task. This doubled the length of the experiment, and participants were reimbursed accordingly.

Data analysis. The data were analyzed using mixed effects models, with participants as a random factor and condition as fixed factor. One model was set up per hypothesis. The data handling procedure is the same as in Experiment 1, as are the models for the main hypotheses and the manipulation check. Additionally, using the new measurement recall time it is investigated whether condition predicts ease of retrieval. Recall time is taken as dependent variable and condition as fixed effect and random intercept, with subjectID and pair name as random slope: lmer(RecallTime ~ condition + (1+condition | subjectID) + (1+ condition | PairName).

Results

In total, 42 participants (78.6% female; M_{age} = 24.07, age range 18-48) successfully completed the experiment. Three participants encountered technical difficulties during the experiment and were excluded as their data were incomplete. All participants completed the practice trials successfully and indicated their understanding. Due to a programming error, one random choice pair in the Control condition was not displayed to each participant. Descriptives of the main variables of the experiment can be found in Table 6.

Table 6.
Descriptives of the main variables in Experiment 2.

Variable	Both conditions *Mean* (SD)	Control condition *Mean* (SD)	Recall condition *Mean* (SD)
Pre-choice value	49.38 (27.50)	49.21 (27.52)	49.55 (27.47)
Post-choice value	47.73 (24.23)	46.79 (24.24)	48.63 (24.19)
Confidence	65.49 (24.86)	63.93 (25.30)	67.99 (24.34)
Pre-choice value difference	0.47 (3.76)	0.47 (3.94)	0.48 (3.58)
Post-choice value difference	16.42 (22.63)	14.89 (22.82)	17.88 (22.35)
	Percentage		
Correct memory	91.9%	88.4%	93.9%
Consistent with initial choice	87.2%	85.8%	88.5%

In Table 7, a sum score per choice pair is created for each choice pair in the stability task. As all pairs were repeated four times in this task, a maximum score of 4 means that the participant was consistent with their initial choice for this choice pair all four times, while 0 means that for this choice pair, the participant never repeated the choice they made initially.

Table 7.
Frequency table of the stability score (0 - 4) of each choice pair in Experiment 2. The score indicates how many choices in the stability task correspond with its initial choice.

Choices consistent with initial choice per pair	Total number of pairs (% of total)	Total number of pairs in Control condition	Total number of pairs in Recall condition
0	152 (6.3%)	95 (8.1%)	56 (4.8%)
1	71 (3.0%)	32 (2.7%)	28 (2.4%)
2	71 (3.0%)	36 (3.1%)	20 (1.7%)
3	183 (7.6%)	76 (6.5%)	50 (4.3%)
4	1917 (80.1%)	928 (79.5%)	1007 (86.8%)

Manipulation checks. Firstly, the Validation choice pairs, which consisted of one extremely high and one extremely low rated food item, were investigated to find out whether participants did the task as intended. Of the 672 choices made, 668 choices were for the high value item, and only 4 for the low-value item. This indicates that participants performed as intended and there was no reason for post hoc exclusion of participants on this basis.

Additionally, it was checked whether the attempt at creating same-value pairs succeeded. The average pre-choice value difference in Experiment 2 was 0.47 (*SD* = 3.76) which indicates that the creation of approximate same-value pairs was successful. This value difference is slightly larger than that in Experiment 1, which can be explained by the creation of groups of three to make pairs, which lead naturally to some pairs with a slightly larger difference. Still, this increase is minimal, and we can regard the choice pairs as critical choice pairs. To investigate whether pre-choice value difference was evenly distributed between conditions a mixed-model approach was used. No significant difference was found (Estimate = -0.004, SE = 0.08, F (1, 42) < 1, $p = 0.95$).

It was then investigated whether the Recall condition in the initial choice task was understood and executed correctly. Out of all Recall trials presented, only 2.9% of choices were recalled incorrectly during the initial choice task. This indicates a proper understanding of the task, and that this task was not too difficult to have the intended effect.

To check whether the intended manipulation of memory was successful in this experiment a mixed model approach was used as described in the method, with the binary score correctness of recall as dependent variable, and condition as independent variable. Correct recall differed significantly between conditions (Estimate = -0.65, SE = 0.25,

χ^2 (1) = 6.29, *p* = .01): pairs in the Recall condition were more often recalled correctly (93.9%) than pairs in the Control condition (88.4%). This indicates that the intended effect of increasing memory through the condition was achieved.

Effect of condition on confidence. To test the first hypothesis, a mixed model approach was used, as described in the method section. Condition was found to have a significant effect on confidence: Estimate = -1.53, SE = 0.58, F (1, 43.19) = 6.92, *p* = .01. Participants indicated higher confidence in choices they made that were in the Recall condition (*M* = 66.99, *SD* = 24.34) than in choices in the Control condition (*M* = 63.92, *SD* = 25.30).

Effect of confidence on stability. Reassessing the effect of confidence on stability, using the mixed model approach described, explicit choice confidence was found to be a significant predictor for stability in that choice (Estimate = .03, SE = 0.01, χ^2 (1) = 26.15, *p* < .001), with higher explicit confidence in the initial choice predicting a higher likelihood to make a choice consistent with the initial choice, as visualized in Figure 10. This, again, replicates the findings of Folke et al. (2016) as well as the findings of Experiment 1, that explicit choice confidence increases choice stability.

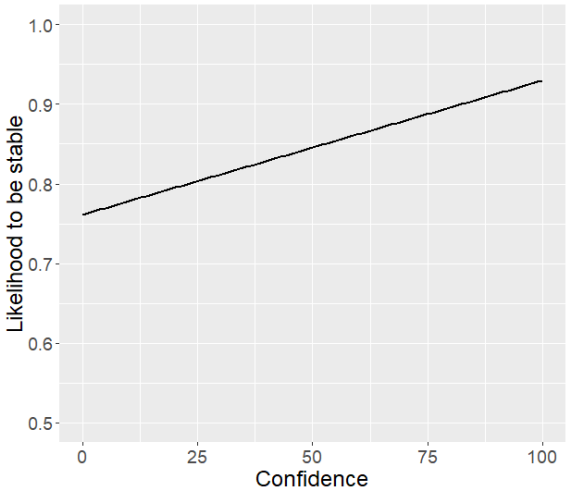

Figure 10. Regression line of the effect of confidence on the likelihood to remain stable.

Effect of condition on stability. A possible direct effect of condition on choice stability was investigated. Using the mixed-model approach described in the method section, it was found that conditions differed in stability: Estimate = -0.28, SE = 0.15, χ^2 (1) = 4.38, p = .04. Choices in the Recall condition were more often stable (88.5%) than choices in the Control condition (85.8%).

Effect of condition on stability mediated by confidence. With these three confirmed hypotheses, mediation testing was done to test whether the direct effect of condition on stability can be explained by choice confidence. This was done by comparing two models. The first model used Stability as a dependent variable, Condition as a fixed effect, had Participant ID and pair name as random intercepts, and the random slope Condition was included for the random intercept Participant ID- the same model as used for the test of the third hypothesis. The second model was the same as the first model, but with Confidence added as fixed effect and random slope for Participant ID. Comparing the direct effects of condition on stability in these models gives insight in confidence as a partial mediator (Fritz & MacKinnon, 2007; Hayes & Scharkow, 2013).

For the first model, the direct effect of condition on stability is significant: Estimate = -0.28, SE = 0.15, χ^2 (1) = 4.38, p = .04. When the mediator confidence is added in the second model, this effect is decreased: Estimate = -0.18, SD = 0.14, χ^2 (4) = 2.29, p = 0.13, making the direct effect of confidence insignificant. To test whether this partial mediation is significant, a Sobel test was conducted. The partial mediation of confidence on the direct effect of confidence on stability was found significant (z = 5.21, p < .001). From this, we can conclude that the relation between condition and stability can partially be explained through confidence.

Effect of condition on recall time.

It was investigated whether the recall time measured in the choice confidence task differed between conditions. This effect was found to not be significant (Estimate = -0.014, SD = 0.04, F (1, 41.09) < 1, *p* = .70), meaning no difference was found between the recall times in the two conditions. Additionally, recall time marginally predicted confidence (Estimate = -0.56, SE = 0.30, F (1, 47.07) = 3.34, *p* = .07. However, in an exploratory manner, all choices for which the reaction time was smaller than 2.5 seconds were removed based on the distribution data, as seen in Figure 11). This excludes all choices for which recall was almost instantaneous: for the cut off values, option selection occurred within 1.5 seconds, plus the mandatory waiting time of 1 second before confirmation was possible. It is unlikely to find any effects of an explicit memory training that aim for increased ease of retrieval when recall is immediate, so we think this cut-off is also theoretically justified. For this subset, the effect of confidence was related to recall time (Estimate = -2.28, SE = 0.43, F (1, 55.76) < .001). Additionally, conditions marginally differed in recall time, with choices in the Recall condition (M = 5.94, SD = 1.53) being remembered marginally faster (Estimate = 0.06, SE = 0.03, F (1, 41.13) = 3.03, p = .09) than those in the Control condition (M = 6.01, SD = 1.55).

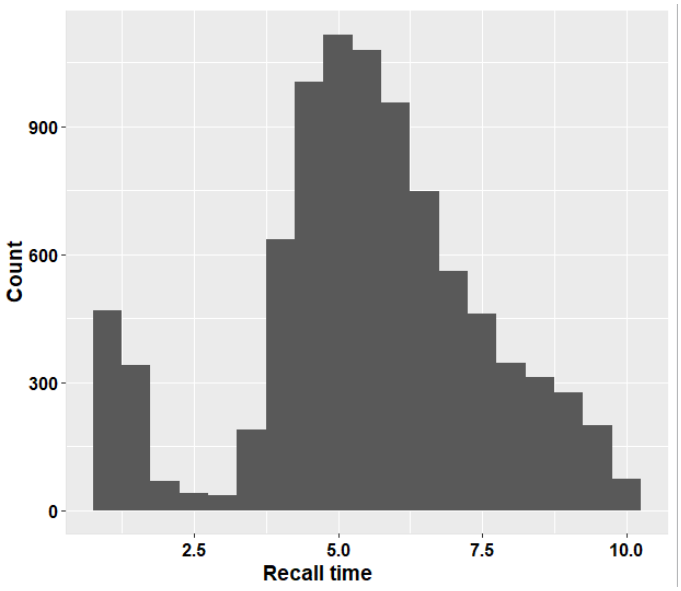

Figure 11. Distribution of responses over recall time (in seconds) corrected for the one second confirmation delay.

The effects of value. Exploratory, the effect of value differences was investigated. Item value shift and post-choice value difference were calculated in the same manner as in Experiment 1. Using a paired sample t-test, it was investigated whether the item value shift for chosen items differed significantly from the item value shift of not chosen items. This difference was significant: t (41) = 5.50, $p < .001$, with the average chosen item going up in value by 6.26 (*SD* = 20.40), but the average not chosen item went down in value by 9.57 (*SD* = 20.31). This was investigated further using a mixed-model approach, with either the chosen or not chosen value as dependent variable, condition as a fixed effect, and participant ID as random intercept, with condition added to it as random slope. No difference based on condition was found for not chosen items: F (1, 48.03) < 1, $p = .88$). However, condition has a significant effect on the value increase of chosen items (Estimate = -1.59, SE = 0.50, F (1, 53.13) = 10.01, $p < .01$), with items in the Recall condition increasing more in value on average (*M* = 7.83, *SD* = 19.78) than items in the Control condition (*M* = 4.63, *SD* = 20.90). These findings are similar to those in Experiment 1.

It was also investigated whether condition predicted post-choice value difference, using a mixed model approach with post-choice value difference as dependent variable, condition as fixed effect and random slope, and participant ID as random intercept. Condition significantly predicts post-choice value difference (Estimate = -1.50, SE = 0.48, F (1, 41) = 9.89, $p < .01$) with choices in the Recall condition having a larger shift (*M* = 17.88, *SD* = 22.35) than those in the Control condition (*M* = 14.89, *SD* = 22.82).

Additionally, it was investigated whether post-choice value difference is related to confidence, using a mixed model approach with post-choice value difference as dependent variable, choice confidence as fixed effect, and participant ID as random intercept. Choice

confidence significantly predicts post-choice value difference (F (1, 60.61) = 47.71, $p < .001$), with the larger the difference, the higher the confidence (Estimate = 0.21, SE = 0.03). In a similar model, it was tested whether post-choice value difference could significantly predict choice stability, which it could (χ^2 (1) = 51.47, $p < .001$). Post-choice value difference and choice stability are positively related (Estimate. = 0.09, SE = 0.01), meaning that the higher the post-choice value difference, the more likely it is for that choice to be stable.

Discussion Experiment 2

In this experiment we attempted to increase choice stability through explicit choice confidence by a manipulation aiming to increase explicit memory in a choice. This manipulation of Recall was successful in creating explicit memory representations this time, with choices in the Recall condition being more often recalled correctly than those in the Control condition. The inclusion of a memory component in the confidence task and the addition of more pairs seem to have had their intended effect. Additionally, the validation of Experiment 2 was successful. Participants did the task as intended, as shown by the check of the Validation choice pairs, and the counterbalancing of choice pairs between conditions was successful, as no difference between conditions in pre-choice value difference was present. This allows us to test the theoretical model.

We found that confidence in the outcome of a choice increased choice stability. The manipulation of explicit memory was successful in increasing confidence in the outcome of choices, and also in increasing choice stability. The effect of the manipulation on choice stability was partially mediated by the confidence in the outcome of the choice. Now that we successfully manipulated an increase in confidence, this study demonstrated these links in a causal experimental setup, building further on the correlational design of Folke et al. (2016).

The results of Experiment 2 serve as replications of Experiment 1 for the effects of confidence on stability, the effect of choice making on value, and the effects of value on confidence and stability. This consistency is both a validation of the task as a confirmation of previous theories.

The hypothesis that recall time can predict confidence was not confirmed, but an exploratory analysis was done with instances near-instant recall removed from the data. Given the significance levels after cut-off, it is possible that the hypothesized effects do exist, and the null results are a consequence of inaccuracy of the used measurement. The measurement included the delay of one second before the confirmation button appeared which can have caused noise in the initial retrieval times. However, this is an exploratory finding and should be replicated before strong conclusions can be drawn from it.

General discussion

The present study sheds new light on the role of confidence in the stability of same-value food choices, and how confidence in outcomes of choices can be increased. In this research, we attempted to increase stability in choices by increasing the confidence in the outcome of these choices. This was done by a manipulation with the goal of increasing explicit memory representation of the outcome of the choice. The designed intervention was a simple active recall intervention, in which participants were asked to remember and recall the choice they made two times. This intervention was successful in creating better memory, higher confidence in the outcome of the choice, and stability in a choice, confirming the theoretical model outlined in the introduction. The implications of the separate relations in the theoretical model are discussed below.

First, this study demonstrates that explicit choice confidence predicts later choice stability. By successfully manipulating an increase in explicit choice confidence, this relationship was demonstrated in a causal manner in Experiment 2. This confirms and expands on the correlational design of the experiment by Folke et al. (2016).

Second, the results of this research demonstrate that increasing explicit memory of the outcome of a choice can increase confidence in that choice, indicating that the recall intervention is successful in increasing confidence. While this intervention was successful in achieving its goal, the current study has not demonstrated exactly how this process works, as the intervention was built on several theories about confidence generation that have been combined into one intervention. Based on the literature, several concepts can explain the effect of the intervention. It can be argued that this process is facilitated by accessibility (Holland et al., 2003; Kelley & Lindsay, 1997), as the higher explicit memory is for a choice,

the more accessible in memory it is, and this accessibility forms a basis for confidence generation. Alternatively, this process can be regulated by item familiarity (Fleming & De Martino, 2014). Increasing explicit memory for an item can make it more familiar, leading to an increase in confidence in the outcome of a choice. A last possible explanation for this process is commitment (Riefer et al., 2017). Being asked to replicate a decision could lead to more commitment to the initial decision, which could in turn increase the confidence in the decision. Promising exploratory results of the relation of recall time and choice confidence indicate accessibility as playing a role in this process, but further confirmatory research is necessary to pin down the mechanics behind this process.

Third, the used recall intervention had an effect on choice stability: participants were more stable in choices that they had been asked to recall before. This was partially mediated by confidence in the choice. These findings signify that choice confidence is an important determinant of choice stability, and that an intervention focused on establishing strong memory representations for initial choices can increase choice stability via choice confidence. The differences between Experiment 1 and Experiment 2 demonstrate the role of memory in the creation of explicit confidence in the outcome of a choice. In Experiment 1, recall was not involved in the rating of explicit choice confidence, due to the way the confidence task was presented. Increasing explicit memory had no effect in this experiment, while in Experiment 2 the task was changed to have participants recall their choice before indicating confidence. With this change, the heightened explicit memory did have an effect on the generation of explicit choice confidence. This indicates that, in order for explicit memory to have an effect on creating confidence in the outcome of a choice, it is necessary that recall is a part of the explicit confidence generation process.

When discussing the previous hypotheses, the possible effects of value should be considered. As discussed before, value was a priori isolated from the choice process in this study to create a design where the effect of confidence could be studied without it being associated with pre-choice value difference. The addition of a post-choice value measure allowed us to investigate how value changes through decision making, and what the relation of post-choice value is with choice confidence. In this regard, both experiments found similar results. Firstly, choosing an item increased its value, while not choosing it decreased its value, corresponding with Bem (1972). Secondly, a larger post-choice value difference was linked to more confidence in a choice (De Martino et al. 2013), and also to larger choice stability.

This increase in value can also be tied directly to the intervention. The results of Experiment 2 show that increasing explicit memory for an item increases its value, as the post-value difference is larger for choice pairs in the Recall condition than those in the Control condition. Both explicit confidence in the choice and post-choice value difference were not affected by a difference between conditions when the recall intervention was not successful in increasing correct memory (Experiment 1). However, when the intervention was successful (Experiment 2) both measures were affected. This indicates that increasing explicit memory representations increases confidence in a choice as well as the post-choice value difference. However, this raises new questions about the relation between choice confidence and value. In both experiments, we found choice confidence and post-choice value difference to be highly correlated, but we cannot further dissect the relationship between these two in this study. It is possible that making a decision leads to an increase in value of the chosen item, which in turn increases confidence in the choice as per the increased value difference (conform De Martino and Fleming, 2010), but the reverse is also

possible: that choice confidence has an effect on the value difference. A different possibility is that both are affected separately. This is especially important because of studies attributing their results to choice confidence, such as Folke et al. (2016) might be doing so without a solid basis, if these results are not controlled for a shift in value due to choice making. Further research is needed to disentangle confidence and value difference during choice making.

Some limitations are applicable to this study. First of all, we need to be conservative in drawing broad conclusions about stability. In this study choice stability is tested after a wait time of five minutes. Calling our findings indicative for the long-term is overstretching, but the effects do implicate possible longer-term effects, which could prove a promising topic for future research and interventions. Furthermore, the sizes of the effects found are relatively small, making them possibly less useful for practical interventions. Finally, further research is necessary to find if these effects persist for non-food items, to see if the effect of the intervention is more generalizable.

In conclusion, a successful intervention based on active recall was designed in the present study to improve explicit memory with the goal of increasing choice confidence and, in turn, choice stability. This intervention was small: it consisted of an explicit memory task, in which it was asked to recall the option that was chosen before. This simple task was enough to increase explicit choice confidence. Moreover, it also increased stability in a choice at least partially through explicit choice confidence.

This study provides both theoretical and practical insights for the effects of explicit choice confidence on choice stability, and the effects of explicit memory in this relation. Theoretically, this study shows how explicit memory plays a role in generating confidence in

the outcome of a choice and can be used to increase subsequent choice stability. This provides an important causal link between choice confidence and later choice stability, while also demonstrating a way to increase choice confidence in an experimental setting. It also sheds light on the close relation of post-choice value and confidence, and the necessity to disentangle these two in further research concerning confidence in the outcome of choices. Practically, it is promising for the design of future interventions with long-term goals that such a small intervention can yield results in choice stability. This research provides an entry towards practical interventions aiming for long-term choice stability, achieving this through explicit choice confidence, using recall as an easy and effective tool to increase confidence via explicit memory representation.

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Appendix A. Script for participant instruction.

Script Experiment 1

Welcome! Thank you for participating in the experiment "Choice, Memory and Liking".

In this experiment you are asked to do all kinds of things with pictures of food. You will be making choices between them, asked to indicate how much you like them, memorize some of them and give your opinion on them.

It is important to keep in mind that at the end of the experiment, one choice you make will be paid out for real. Therefore, you should treat them as real choices!

Because you are given a snack at the end of the experiment, it is very important that you do not have any food allergies or other food restrictions.

There are a few times in the experiment that you can come and get me. This will be indicated in the task. For one task, there will be practice trials and I will be with you when you do these, to make sure you understand the task correctly. Also, when the break starts, you can come and get me so we can discuss any difficulties you may encounter.

If you have any questions, please do not hesitate to ask them. You can stop the experiment at any time without negative consequences for you. Please sign the consent form before we start the experiment. This consent form states that you have been informed sufficiently, that you can leave at any time during the experiment without negative repercussions, and that you do not have food restrictions.

Good luck!

(For the practice trials of the initial choice task)

In this task you will be asked to make choices and to memorize some of them, indicated by the border colour when you select a choice. Remember, one of the choices will be selected from a subset we have available here and given to you at the end of the experiment! I will be standing here to watch whether you understand, and you can ask me questions if there is something you do not understand. Please follow the instructions on screen now.

(For the break)

Do you have any questions? Did you encounter any problems? After the break, a task starts in which you will be making more choices. Please remember that one of the choices made in this experiment will be paid out to you at the end of the experiment.

(After the experiment)

Thank you for participating! Did you encounter any problems? What snack did the program select for you?

During the last task, the memory task, you were asked to recall a choice that you made earlier. Did this task ask to recall a choice you made during the task before or during the task after the break?

You can leave your info behind if you want to be debriefed about the results of the experiment. If you are here for an iris cheque, please fill in this form.

Script Experiment 2

Welcome! Thank you for participating in the experiment "Choice, Memory and Liking II".

In this experiment you are asked to do all kinds of things with pictures of food. You will be making choices between them, asked to indicate how much you like them, memorize some of them and give your opinion on them.

It is important to keep in mind that at the end of the experiment, one choice you make will be paid out, out of a subset of items we have available here. Therefore, you should treat them as real choices!

Because you are given a snack at the end of the experiment, it is very important that you do not have any food allergies or other food restrictions.

There are a few times in the experiment that you can come and get me. This will be indicated in the task. For two tasks in the experiment, there are practice trials and I will be with you when you do these, to make sure you understand the task correctly. Also, when the break starts, you can come and get me so we can discuss any difficulties you may encounter.

If you have any questions, please do not hesitate to ask them. You can stop the experiment at any time without negative consequences for you. Please sign the consent form before we start the experiment. . This consent form states that you have been informed sufficiently, that you can leave at any time during the experiment without negative repercussions, and that you do not have food restrictions.

Good luck!

(For the practice trials of the initial choice task)

In this task you will be asked to make choices and to memorize some of them, indicated by the border colour when you select a choice. Remember, one of the choices will be selected from a subset we have available here and given to you at the end of the experiment! I will be standing here to watch whether you understand, and you can ask me questions if there is something you do not understand. Please follow the instructions on screen now.

(For the practice trials of the confidence task)

In this task you are asked to memorize the choice. If you made a selection, but made a mistake, you can still change as long as you did not press the confirm button. Then, you are asked how confident you are that you indeed like the chosen item over the other one. Please note that the question is NOT how sure you are you remember correctly, but how sure you are that you like the item over the other.

(For the break)

Do you have any questions? Did you encounter any problems? After the break, the final task starts in which you will be making more choices. Please remember that one of the choices made in this experiment will be paid out to you out of a subset of available items.

(After the experiment)

Thank you for participating! Did you encounter any problems? What snack did the program select for you? You can leave your info behind if you want to be debriefed about the results of the experiment. If you are here for an iris cheque, please fill in this form.