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Exploring the Underpinning Mechanisms of the Proximity Effect within a Competitive Food Environment

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**Abstract**

*Objective*: One method of influencing an individual’s food consumption involves placing unhealthysnacks further away from individuals, known as the “proximity effect”. However, only one laboratory study has explored the effect while both an unhealthy and a healthy option are presented simultaneously. Further, little is known about the potential underpinning mechanisms of the effect. The current study aims to replicate the proximity effect in a competitive environment, and to explore the role of visual salience and effort in the proximity effect.

*Method*: Fifty-six participants were asked to complete a two-part questionnaire under the cover storyof a relaxation study. Two bowls were presented to participants, each containing either 250g chocolate M&M’s or 250g mixed fruit pieces. Each bowl was positioned either 20cm or 70cm from the participant, creating four proximity conditions. Consumption of each snack was compared between proximity conditions.

*Results*: No main effects were found. A significant interaction between snack type and chocolateposition was found (*p* = .010, ȵ = .159), with fruit consumption being significantly higher when chocolate was at located at 20cm compared to 70cm (53.35g vs 22.35g, *p* = .042). Higher visual salience of each snack type correlated to more of the snack being consumed, *p*s < .017. Results were similar when calories consumed were analysed.

*Conclusions*: We found an unconventional proximity effect where the consumption of a snack did notdepend on its position, but rather the relative position of another snack. Implications of the study could inform café and supermarket layouts to exploit the interaction between moving healthy items closer in addition to moving unhealthy items further away, in order to maximise choice of healthy items.

**Key Words:** Proximity, Nudging, Competitive Environment, Salience, Effort, Behaviour Change

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| 1 | **Introduction** |
| 2 |  |
| 3 | Rates of individuals with obesity have risen across the globe at a yearly rate for many decades |



* (Di Cesare et al., 2016; Ng, Fleming, Robinson, Thomson, & Graetz, 2014), with almost a third of the
* global population overweight or obese in 2014. Traditional methods of controlling and reducing
* obesity, such as public-health campaigns and communicating genetic risk factors, have been found to
* be largely ineffective (Marteau et al., 2010; McKinsey Global Institute, 2014). Therefore, many
* researchers have suggested investigating the effectiveness of non-conscious behaviour change
* strategies (Hagger, 2016; Marteau, Hollands, & Fletcher, 2012; Vlaev et al., 2016). One promising

1. method utilises behavioural economics to influence non-conscious decision making, often referred to
2. as ‘Nudging’ (Hansen, 2016; Thaler & Sunstein, 2008 ). In particular, one under-researched (Hollands
3. et al., 2013) yet promising area of nudging involves placing foods further away from the consumer to
4. decrease consumption and selection, defined as the ‘Proximity Effect’ (Bucher et al., 2016; Maas, de
5. Ridder, de Vet, & de Wit, 2012; Privitera & Zuraikat, 2014). The present study aims to explore the
6. proximity effect while individuals are presented with two snacks of opposing healthiness, and to
7. further the understanding of the mechanisms which may underpin the proximity effect, specifically
8. visual salience and perceived effort.
9. A recent review of proximity and placement literature by Bucher et al., (2016) concluded that
10. while evidence which suggests an increase in distance reduces consumption is consistent, more work
11. should be conducted to explore the mechanisms which make the effect occur. The effect has been
12. observed over a range of distances, from larger lunchrooms (Meiselman, Hedderley, Staddon, Pierson,
13. & Symonds, 1994; Vanata, Ph, Hatch, & Depalma, 2011) to much smaller distances typically seen
14. within a regular lab or kitchen (20cm - 70cm, Maas et al., 2012; 30cm - 2m, Privitera & Creary, 2013;
15. Privitera & Zuraikat, 2014). Maas and colleagues suggested the proximity effect may occur within a
16. threshold, where consumption is reduced when snacks are placed at 70cm or further from the
17. individual. These distances of 20cm and 70cm have since been used by Hunter, Hollands, Couturier,
18. and Marteau, (2018) while determining that the proximity effect is unlikely to be moderated by
19. cognitive load. However, as research using these distances is relatively scarce, further research should
20. be conducted using these distances to determine whether the effect can be observed between 20cm as
21. 70cm as suggested by Maas and colleagues. A potential explanation is offered by Trope and Liberman
22. (2010), who suggest that individuals are more sensitive to changes physically closer to themselves
23. compared to changes physically further away from themselves, and may explain why the proximity
24. effect occurs in relatively small distances.
25. While Hunter and colleagues found that cognitive load is unlikely to moderate the proximity
26. effect, previous research has set out to explore the mechanisms which may cause the proximity effect

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1. to occur, with prior work by Wansink and colleagues (Painter, Wansink, & Hieggelke, 2002;
2. Wansink, Painter, & Lee, 2006) suggesting visibility may moderate the proximity effect. Their studies
3. found consumption of chocolates was highest when chocolates were positioned proximate and visible
4. to the consumer, rather than when chocolates were proximate but not visible. Further, individuals
5. rated chocolates as attracting more attention and being easier to eat when proximate and visible than
6. when solely proximate, solely visible, or neither proximate nor visible. Hence, it was proposed that
7. visibility may moderate the proximity effect. Contrary to the aforementioned findings, Maas et al.,
8. (2012) saw that while consumption of chocolate M&M’s were higher when placed closer, participants
9. rated visual salience of proximal and distal M&M’s to be similar, and so not thought to influence the
10. amount of M&M’s consumed. Additionally, Maas et al. (2012) also measured the effort which
11. individuals perceived was required to consume the M&M’s from each distance, finding that more
12. effort was required to attain M&M’s from a distal position than proximal. This was also found more
13. recently by Hunter et al. (2018), leading to perceived effort being considered as another potential
14. mechanism which may moderate the proximity effect. Past studies (Hunter et al., 2018; Maas et al.,
15. 2012) have measured visual salience and perceived effort, but did not use the results to directly
16. explore the relationship between distance and perceptions of effort and saliency at different distances.
17. As no research at present has been conducted to specifically explore how the mechanisms of visual
18. salience and perceived effort may influence the proximity effect, future research should aim to
19. explore the underpinning mechanisms to fully understand the proximity effect.
20. In addition to exploring the underlying mechanism of the proximity effect, researchers must
21. also consider the food environment in which they are testing the proximity effect. Most proximity
22. effect studies commonly use only one type of snack, often chocolate such as M&M’s (Hunter et al.,
23. 2018; Maas et al., 2012; Wansink et al., 2006). While researchers have demonstrated proximity and
24. positional effects in field studies with multiple snack types (Baskin et al., 2016; Kroese, Marchiori, &
25. De Ridder, 2016), very few laboratory-based proximity studies were conducted with both healthy and
26. unhealthy snacks presented together, referred to as a competitive food environment (Langlet,
27. Fagerberg, Glossner, & Ioakimidis, 2017; Privitera & Zuraikat, 2014). A competitive environment is
28. more similar to food layouts in cafes and supermarkets than when single foods are presented, allowing
29. researchers to explore possible interactions between selection and consumption of different food types
30. when presented together. Further, a competitive environment can enable researchers to deduce
31. whether food preference influences consumption, or whether presentation position can be stronger
32. than which food an individual usually prefers. Therefore, more research exploring the proximity effect
33. should be conducted while individuals are offered multiple foods or snacks, rather than simply being
34. offered only one snack type.
35. Privitera and Zuraikat (2014) conducted the first competitive environment laboratory study,
36. finding that while participants much preferred buttered popcorn, apple slice consumption was

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1. significantly higher than that of popcorn when apple slices were placed closer (30cm) than popcorn
2. (2m). This finding illustrated that the proximity effect can occur regardless of food preference, as the
3. lesser preferred food was consumed significantly more than the preferred food by simply placing one
4. closer than the other. However, effort and salience were not assessed in this study, and so it is not
5. known whether either of these mechanisms could have influenced snack consumption and the
6. proximity effect. Future studies should aim to use the measures of visual salience and perceived effort
7. for snacks presented simultaneously but at various distances to ascertain whether the role of effort or
8. salience may underpin or moderate the proximity effect.

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1. Aims and Hypotheses
2. The present study aims to apply the measures of visual salience and perceived effort to a
3. competitive environment in order to deduce whether these factors influence the proximity effect in a
4. competitive environment. Additionally, the current study will be the first to explore the proximity
5. effect in a competitive environment at distances within arm’s reach (20cm-70cm), rather than the
6. larger relative distances between snacks used by Privitera and Zuraikat (30cm-200cm). The primary
7. aim of the present study is to explore the proximity effect in a competitive food environment between
8. a healthier fruit snack, and an unhealthier, chocolate snack presented at either 20cm (proximal) or
9. 70cm (distal) from the participant. The distances of 20cm and 70cm have previously been used by
10. Maas et al., (2012) and Hunter et al., (2018), illustrating that the effect can occur with a single food
11. within these distances, whereas Privitera & Zuraikat, (2014) found a significant proximity effect
12. between snacks presented at 30cm and 200cm. Further, the study will explore the moderating role of
13. the visual salience and perceived effort as a secondary aim. The hypotheses for the study can be
14. expressed by the following:
15. H1: Consumption of the snacks will be significantly higher when presented at a proximal
16. (20cm) distance than distal (70cm), regardless of food type, in line with previous findings
17. (Bucher et al., 2016).
18. H2: Overall, participants will consume significantly more of the chocolate snack (unhealthier)
19. compared to the fruit snack (healthier), as Rozin, Levine, and Stoess (1991) found that
20. chocolate has consistently high hedonic ratings, in addition to Privitera and Zuraikat (2014)
21. finding participants rated buttered popcorn more favourably than fruit.
22. H3: There will be a significant interaction between snack type and proximity, with chocolate
23. presented proximally being consumed more than fruit presented distally, similar to Privitera
24. and Zuraikat (2014).

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| 105 | H4: It is hypothesised that the proximity effect will be moderated by either visual salience, |
| 106 | perceived effort, or an interaction between the two, as past research has suggested each of |
| 107 | these factors may independently influence the proximity effect (Maas et al., 2012; Wansink et |
| 108 | al., 2006). |
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110 **Method**

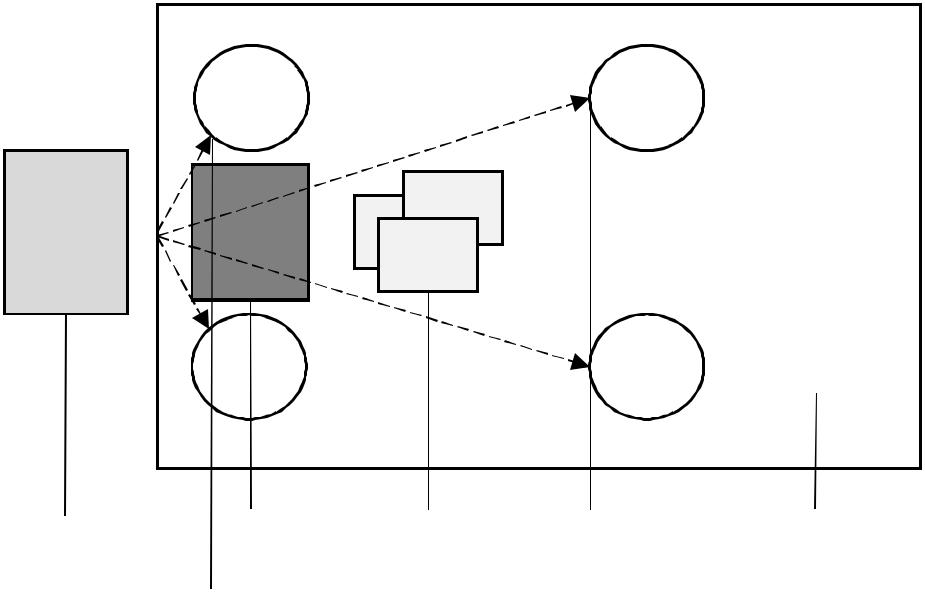
111

1. Participants and Recruitment
2. The study recruited students from a university in the Midlands, UK, via the research
3. participation scheme at the institution; participants were rewarded with 30 minutes’ worth of credits
4. for their participation. Participants with known food allergies, intolerances, and other food-related
5. illnesses (including but not limited to nuts, soya, lactose, wheat, oats, and gluten) were excluded from
6. participation. The study was advertised as a relaxation study (as in Maas et al., 2012), in order to
7. reduce demand characteristics. Further, participants were asked to refrain from eating for two hours
8. prior to participation. Power analysis was conducted using the Privitera and Zuraikat’s (2014) effect
9. sizes of *d* = 1.16 and *d* = 1.25, setting α = .05. In order to achieve power = .80, the required sample
10. size was between 36 and 56. The study was powered to detect difference between the weight of each
11. snack consumed, and was not powered to detect differences between participant characteristics (i.e.
12. BMI), or to detect differences in calorie consumption. As the sample size was required to be a
13. multiple of eight due to the experimental design, a main sample size of N = 48 was desired, with the
14. provision that oversampling was carried out to replace participants who moved their bowls (and
15. therefore not following the intended procedure) . This resulted in N = 56 participants being recruited in
16. total, in keeping with the associated study protocol (Knowles, Brown, & Aldrovandi, 2017).
17. The overall sample recruited for the study contained a large majority of female participants
18. (83.9%), with an overall mean age of M = 21.73 years (SD = 7.07), and mean BMI of 24.92 (SD =
19. 5.09). Most of the sample (92.9%, N = 52) were undergraduate students, with four individuals (7.1%)
20. possessing a post-graduate degree. Half (50%, N = 28) of the overall sample identified as White
21. British. Condition-level descriptive results and a more detailed breakdown of demographics can be
22. found in table 1 (See Table 1, and Online Supplementary Material (OLSM) 1).
23. Design
24. A fully-factorial design manipulating three variables was implemented, in a 2 (Snack Type;
25. Healthy [fruit] vs Unhealthy [chocolate], within-subjects) x 2 (Fruit position; proximal [20cm] vs
26. distal [70cm], between-subjects) x 2 (Chocolate position; proximal [20cm] vs distal [70cm], between-
27. subjects) mixed design, resulting in four conditions where both snack types were presented
28. simultaneously (Both snack types proximal, Fruit proximal, Chocolate proximal, and both snack types
29. distal). A fully factorial design was required in order to test and account for main effects of the
30. position of each snack type. A computer generated number sequence was used to assign participants
31. randomly to one of four conditions (fruit position x chocolate position). Sex and BMI were not
32. controlled for when randomising to conditions, but BMI and frequency of males and females were

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1. similar across all conditions (See Table 1). Within each trial, participants were presented with two
2. clear 15cm bowls, each containing either 250g (+/- .5g) of fruit or chocolate M&M’s, and presented at
3. either a proximal (20cm) or distal (70cm) position. The distance was measured from the edge of the
4. table closest to the participant to the front edge of the bowl closest to the participant (see Figure 1). A
5. small selection of magazines about neutral content were located on the table (see also Hunter et al.,
6. 2018; Maas et al., 2012). A 13” laptop was placed o n the table in front of the participant to allow them
7. to complete the questionnaire on using the built-in keyboard and mouse. Presentation side of each
8. snack was counterbalanced, with the fruit being presented on the left side of the table and the right



Participant

Laptop Magazines

70cm Bowl

Table

Seat

Position

20cm Bowl

Position

1. side of the table in an equal number of trials.
2. *Figure 1.* Layout of testing area
3. Materials
4. *Snack Stimuli*: In the study, the unhealthier, chocolate snack was a 250g bowl of chocolate
5. M&M’s ® (Mars, 480kCal per 100g). The healthier, fr uit snack consisted of apple slices, grapes, and
6. small orange segments, weighing 250g in total. Apple slices were cut from Gala apples (53.3kCal per
7. 100g), with the core removed and sliced into pieces of around 6-10g (estimated 3-5kCal per piece).
8. Green and red grapes (72kCal per 100g) were removed from their vine and presented loose in the
9. bowl. Orange segments consisted of peeled orange segments (“EasyPeel Jaffa”; 47kCal per 100g)
10. placed loose in the bowl. These fruits were chosen to be similar in visual salience to the M&M’s. The
11. bowls were weighed on a digital laboratory scale to the closest .01g. Mean energy (kCal) of the fruit
12. bowls was estimated to be 138kCal per 250g, compared to 1200kCal for the bowl of M&M’s.

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164 *Questionnaire Measures*: Participants were asked to complete a short computerised

1. questionnaire presented on a laptop (See OLSM 2).
2. *Perceived Effort:* Perceived effort for each snack type was assessed with five Likert-scale

167 items (i.e. The was within easy reach, with Fruit and Chocolate filling the space), anchored

1. by 1 = Not at All, and 5 = Very Much. Items 2 and 4 were reverse scored, with the mean for each
2. participant being calculated and used for subsequent analysis. Maas et al., (2012) previously stated the
3. Cronbach’s α for the measure is α = 0.89.
4. *Visual Salience:* Visual salience for each snack type was measured with five Likert-scale

172 items (i.e. The looked irresistible, again with Fruit or Chocolate filling the space when

1. required), anchored by 1 = Not at All, and 5 = Very Much. Items 2 and 5 were reverse scored, with
2. the mean of the items for each participant being used for subsequent analysis. The Cronbach’s α of the
3. measures has previously been stated by Maas et al. (2012) to be α = 0.83.
4. *Stress:* The Perceived Stress Scale-short version was used as part of the relaxation cover story
5. (i.e. How often have you felt that things were going your way?), with the four items being scored on a
6. Likert-scale, anchored with 1 = Never, and 5 = Very Often (Cohen, Kamarck, & Mermelstein, 1983).
7. Items were asked before and after the relaxation break in order to provide a more convincing cover
8. story, with previous Cronbach’s α of the measures being reported as α = 0.6 (Lee, 2012).
9. *Tiredness:* Tiredness was measured by a single item, asking participants how tired they
10. currently feel on a 1 (Not tired at all) – 7 (Very tired) Likert scale. Tiredness was measured twice to
11. measure any differences between before and after the relaxation/snacking period.
12. *Hunger:* Hunger was measured with a single item, asking participants how hungry they
13. currently feel on a 1 (Not hungry at all) – 7 (Very hungry) Likert scale. Hunger was measured twice
14. to determine whether hunger levels changed after the snacking period.
15. *Impulse Control:* Impulse control, a short measure for executive functioning, was measured
16. using 6 items (i.e. Do you find it difficult to keep your attention on a particular task?), scored from 1
17. (Not like me at all) to 5 (Very much like me), adapted from Hunter et al., (2018). The mean of the
18. answers for each individual was used as a total score for analysis.
19. *Handedness*: The Edinburgh Handedness Inventory (Veale, 2014) was used to measure
20. handedness, asking participants which hand they commonly use to write, thrown an object, brush their
21. teeth, and eat with a spoon, anchored by 1 = Always left, and 5 = Always right. The mean of the
22. answers for each individual was used as a total score for analysis.

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195 *Food Liking*: Food liking was measured by asking participants how pleasant a mouthful of a

1. variety of 10 snacks would be on a 100-point VAS, anchored with “Not pleasant at all” and “Very
2. Pleasant”.
3. *Study Awareness:* Awareness of the true intent of the study was measured by asking
4. participants to write what they believed the study was measuring, in an open ended question allowing
5. individuals to type their answer.
6. *Nudge Acceptability:* Individuals were asked 7 items relating to how accepting they would be
7. in the given scenario (i.e. If a drinks manufacturer placed labels warning you of the risk consuming
8. too much sugar and educating you on the risks, I would be…), with items based on Petrescu,
9. Hollands, Couturier, Ng, and Marteau (2016). Items were scored on a 5-point Likert scale, anchored
10. by 1 = Not in favour, and 5 = very in favour.
11. *Demographics:* Individuals were asked to input their age (numerical value in years), their sex
12. (Male, Female, Prefer not to say), which ethnicity they identify with (dropdown boxes with ONS
13. recommended categories), their education level (From “No qualifications” to “Post-graduate
14. Degree”), and their non-term-time postcode. BMI was also calculated through measuring participants’
15. height and weight.
16. Procedure
17. Participants who volunteered and met the study criteria attended a single 30-minute
18. laboratory individual session, taking place between 10:00 and 16:00 on weekdays in Summer-Autumn
19. 2017. Once participants were comfortably seated and provided consent, the researcher asked the
20. participant to complete the first of a two-part questionnaire, allowing 10 minutes to do so. Magazines
21. of neutral content were placed on the table to allow participants to browse through them if participants
22. completed the questionnaire before the indicated time allowance. Participants were informed that the
23. snacks on the table were fresh, and that they could consume the snacks freely. The first part of the
24. questionnaire to be completed in this section consisted of questions on age, sex, socio-economic
25. position (SEP), tiredness, hunger, daily stressors, executive functioning, and handedness presented in
26. the specified order, and were completed while snacks were present. The researcher answered any
27. questions the participant had at the beginning of the session, then excused themselves from the room
28. to file away consent documentation. Upon return after 10 minutes, the researcher asked the participant
29. to complete the second half of the questionnaire. The second half consisted of questions relating to
30. tiredness and hunger, subjective food liking of ten snacks, perceived effort of reaching each bowl,
31. visual salience of each bowl, ethnicity, awareness of the study, acceptability of nudges, and BMI
32. measurements, and were completed when snacks had been removed. Tiredness and hunger questions
33. were asked on both halves of the questionnaire in order to calculate whether hunger and tiredness
34. scores changed after consuming any snacks, as well as to strengthen the cover story of exploring

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1. factors which may influence stress and relaxation. At this time, the researcher removed the bowls
2. from the table and excused themselves again in order to collect debrief information and prepare
3. snacks for the next trial. While out of the laboratory, the researcher weighed the bowls using a digital
4. weighing scale and recorded their weight. The researcher then returned to the laboratory to complete
5. the session by measuring the participant’s height and weight. Participants’ BMI was calculated using
6. a digital weighing scale to the nearest 0.1kg and a stadiometer measuring height in cm. Once this was
7. completed, the participant was fully debriefed and thanked for their time.

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1. Data Analysis
2. *Primary Outcome:* As stated in the protocol (Knowles et al., 2017), consumption of each
3. snack was measured in grams, calculated by the difference in weight of each bowl between the start
4. and end of each trial. Calories consumed was calculated by multiplying the weight of the fruit (g) by
5. .553, and multiplying the weight of the chocolate (g) by 4.8, resulting in the calories (kCal) per snack
6. type respectively. Individuals who moved either bowl were removed from main analysis, but included
7. in later sensitivity analysis. Prior to analysis, a manipulation check was conducted, using a 2x2
8. ANOVA to compare conditions for variables from the questionnaire (i.e. BMI, hunger, etc.). The
9. main analysis to test for differences in snack consumption was a 2(fruit position; 20cm, 70cm) x 2
10. (fruit position; 20cm vs 70cm) x 2(chocolate position; 20cm, 70cm) between-subjects ANCOVA. As
11. visual salience and perceived effort have previously been identified as potential underpinning
12. mechanisms, these variables were planned to be included in main analysis. Post-hoc testing with
13. Bonferroni corrections were carried out to explore significant interactions from the ANCOVA, with
14. correlational analysis being conducted to explore any significant covariates in the analysis. Main
15. analysis was repeated for exploratory sensitivity analysis to examine the effect of inclusion of outliers
16. and those who moved the bowls. In addition to the analyses outlined in the associated protocol
17. (Knowles et al., 2017), the main analysis (2x2x2 ANCOVA) was repeated with calorie consumption
18. as the dependant variable, as calories consumed was reported by Privitera and Zuraikat (2014), and is
19. often considered to be of public health interest. Outcomes from both sets of analyses are presented.
20. All analysis was conducted in SPSS version 24.
21. *Additional outcomes:* Planned data analyses were stated in the corresponding study protocol
22. (Knowles et al., 2017), stating that descriptive analysis on age, BMI, frequency of gender, and
23. frequency of ethnicity would be conducted. Factorial ANOVA tests were conducted to identify
24. whether experimental conditions were similar for participant characteristics (i.e. tiredness, hunger,
25. age, stress). Any characteristics which were significantly different across conditions would be
26. included in the main analysis as a covariate.

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264 **Results**

1. **Descriptive Analysis**
2. Eight participants were removed from the analysis as they moved either bowl (as in Hunter et
3. al., 2018), resulting in N = 48 participants being included in main analysis (See Table 1). Results are
4. the same as when N = 56 participants are included, unless otherwise stated.
5. Table 1. *Demographic and characteristic data of participants*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Characteristic | |  |  | Condition |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  | Both | Fruit | Chocolate | Both | Overall | Overall |  |
|  |  |  | Proximal | Proximal | Proximal | Distal | (Non-bowl | (Including |  |
|  |  |  |  |  |  |  | Movers) | Bowl |  |
|  |  |  |  |  |  |  |  | Movers) |  |
| Participants (N) | |  | 11 | 12 | 13 | 12 | 48 | 56 |  |
| Sex (N (%)) | | Male | 2 (18.2%) | 1 (8.3%) | 3 (23.1%) | 1 | 7 (14.6%) | 9 (16.1%) |  |
|  |  |  |  |  |  | (8.3%) |  |  |  |
|  |  | Female | 9 (81.8%) | 11 (91.7%) | 10 (76.9%) | 11 | 41 (85.4%) | 47 (83.9%) |  |
|  |  |  |  |  |  | (91.7%) |  |  |  |
| Age (M, (SD)) | |  | 21.27 | 21.58 | 19.31 (1.11) | 20.17 | 20.54 | 21.73 (7.07) |  |
|  |  |  | (2.53) | (5.58) |  | (3.90) | (3.66) |  |  |
| BMI (M, (SD)) | |  | 26.07 | 24.38 | 24.16 (4.26) | 23.66 | 24.55 | 24.92 (5.09) |  |
|  |  |  | (4.18) | (5.29) |  | (3.07) | (4.20) |  |  |
| Tiredness (M (SD)) | | Before Snacks | 3.55 | 4.67 (1.72) | 3.69 (1.55) | 4.23 | 4.04 (1.62) | 3.96 (1.61) |  |
|  |  |  | (1.51) |  |  | (1.66) |  |  |  |
|  |  | After Snacks | 2.64 | 3.17 (1.27) | 2.85 (1.07) | 3.00 | 2.92 (1.15) | 2.79 (1.14) |  |
|  |  |  | (1.12) |  |  | (1.21) |  |  |  |
| Hunger (M (SD)) | | Before Snacks | 3.09 | 4.00 (1.60) | 4.69 (1.49) | 3.50 | 3.85 (1.60) | 3.93 (1.61) |  |
|  |  |  | (1.38) |  |  | (1.62) |  |  |  |
|  |  | After Snacks | 2.00 | 2.17 (1.27) | 2.62 (1.19) | 2.08 | 2.23 (1.10) | 2.23 (1.08) |  |
|  |  |  | (1.18) |  |  | (.70) |  |  |  |
| Stress (M (SD)) | |  | 3.27 (.62) | 3.68 (.43) | 3.55 (.42) | 3.39 | 3.48 (.51) | 3.46 (.51) |  |
|  |  |  |  |  |  | (.52) |  |  |  |
| Executive Functioning | |  | 3.12 (.83) | 3.40 (.73) | 3.18 (.91) | 2.85 | 3.14 (.83) | 3.16 (.82) |  |
| (M (SD)) | |  |  |  |  | (.83) |  |  |  |
| Nudge Acceptability | |  | 3.95 (.68) | 3.40 (.51) | 3.78 (.67) | 3.61 | 3.68 (.64) | 3.72 (.62) |  |
| (M (SD)) | |  |  |  |  | (.61) |  |  |  |
| Handedness | |  | 4.43 | 4.95 |  | 4.67 | 4.34 |  |  |
| *M* (SD) | |  | (.99)\* | (.10)\* | 3.38 (1.66)\* | (.86) | (1.21) | 4.42 (1.14) |  |
| Effort (Fruit) *M* (SD) | |  | 1.84 | 1.22 | 2.74 | 2.67 | 2.13 |  |  |
|  |  |  | (.77) | (.42)\*\* | (1.01)\*\* | (.93)\* | (1.02) | 2.21 (1.03) |  |
|  |  |  |  |
| Effort (Chocolate) *M* | |  | 1.89 | 3.05 |  | 2.38 |  |  |  |
| (SD) |  |  | (.78)\* | (.84)\* | 1.80 (.68)\* | (.77) | 2.28 (.90) | 2.27 (.94) |  |
| Salience (Fruit) *M* | |  | 3.38 |  |  | 2.90 |  |  |  |
| (SD) |  |  | (1.01) | 3.47 (.77) | 3.11 (.87) | (.94) | 3.21 (.89) | 3.28 (.93) |  |
| Salience (Chocolate) | |  | 3.00 |  |  | 3.48 | 3.33 |  |  |
| *M* (SD) | |  | (1.09) | 3.00 (.81) | 3.78 (.94) | (1.25) | (1.06) | 3.31 (1.06) |  |
|  | : 1 = left handed, 5 = right handed, \* *p* < .05, \*\* *p* < .001 | | | |  |  |  |  |  |

= ", = Proposed Process Variable

1. Manipulation Check

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271 In order to assess if group randomisation were successful, factorial ANOVAs were conducted

1. on each of the following variables: Age, BMI, tiredness, hunger, stress, executive functioning,
2. handedness, and nudge acceptability. These analyses showed a main effect of fruit position on
3. handedness, *F*(1, 44) = 4.23, *p* = .046, ȵ = .088, with scores being on average more right-handed
4. when the fruit was at 20cm (M = 4.71, SD = .72) than when at 70cm (M = 4.00, SD = 1.46). A main
5. effect of chocolate position approached significance, *F*(1,44) = 4.04, *p* = .051, ȵ = .084, with
6. participants being more right handed in the conditions where the chocolate was at 70cm (M = 4.69,
7. SD = .84) compared to 20cm (M = 3.99, SD = 1.43).Therefore, handedness was included as a
8. covariate in subsequent analyses. No other characteristic variable was significantly different across
9. conditions, all *p*s > .061.
10. Participants were significantly less tired in the second part of the study (after snacks) than the
11. first part, all *p*s < .05, apart from the chocolate proximal condition, *t*(12) = 2.09, *p* = .059, and were
12. significantly less hungry after snacks in every condition, all *p*s < .05. Most participants did not
13. correctly guess the true intent of the study, as only four participants believed the study was
14. investigating whether snack position affects its consumption; as these participants were equally
15. distributed across conditions, the potential confounding effect was rather limited. Removal of these
16. individuals did not change the outcomes and results of the study (See OLSM 3).
17. Individuals rated both the fruit and the chocolates as requiring more effort to attain when
18. positioned at 20cm compared to 70cm (See Table 1). Visual Salience scores were similar across all
19. conditions, showing that snacks were similarly salient regardless of position (See Table 1). Moreover,
20. individuals stated that chocolate had a higher liking rating than both apple slices and orange segments.
21. Analysis results are presented in the supplementary materials (See OLSM 3).
22. Snack Consumption
23. *Primary Outcomes (Grams):* No main effects of position for either snack were found, all *p*s >
24. .313, indicating there was no traditional proximity effect. There was a significant interaction between
25. snack type and chocolate position, *F*(1, 39) = 7.35, *p* = .010, ȵ = .159, with Bonferroni corrected
26. post hoc tests showing that fruit consumption was lower when the chocolate was presented at 20cm
27. (*M =* 22.35g, SE = 8.92g) than 70cm (*M =* 53.35g, SE = 9.08g), *F*(1,39) = 4.44, *p* = .042, *d* = 0.70
28. (See Figure 2). Further, more fruit (*M =* 53.35g, SE = 9.08g) was consumed than chocolate (*M =*
29. 9.45g, SE = 5.78g) when chocolate was presented at 70cm, *p* < .001, *d* = 1.16, regardless of fruit
30. position (See Figure 3). Thus, fruit consumption was dependent on the position of the chocolate, with
31. more fruit being consumed when the chocolate was at the 70cm, with the position of the fruit not
32. influencing consumption. All inferential outcomes are available in the supplementary materials (See
33. OLSM 3).

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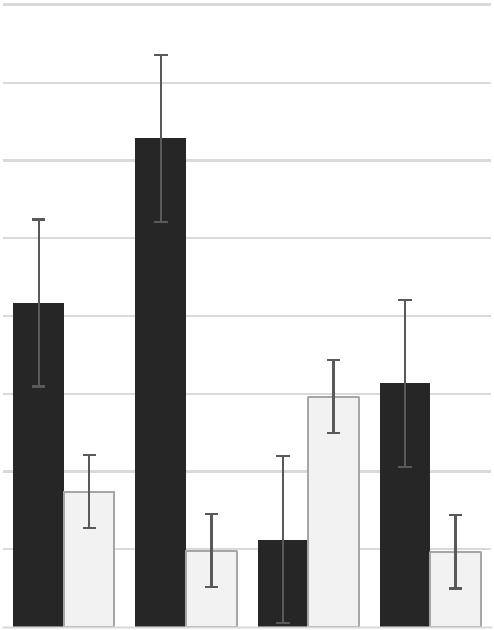
305 *Primary Outcome (Calories)*: Calorie consumption per trial was calculated, with a 2x2x2 (as

1. above) being conducted. No main effects were found, *p*s < .273. An interaction between snack type
2. and chocolate position approached significance, *F*(1, 39) = 3.650, *p* = .063, ȵ = 0.86, with more fruit
3. consumed when the chocolate was positioned at 70cm than 20cm, as in previous main analysis (See
4. Figure 2). When total calories consumed in each trial were calculated and analysed, there were no
5. significant differences between conditions, with no main effects or interactions found, *p*s > .114.

311

312

|  |  |  |
| --- | --- | --- |
| A | 80 |  |
|  | 70 |  |
|  | 60 |  |
| (g) | 50 |  |
| Consumption |  |
| 40 |  |
|  |  |



30

20

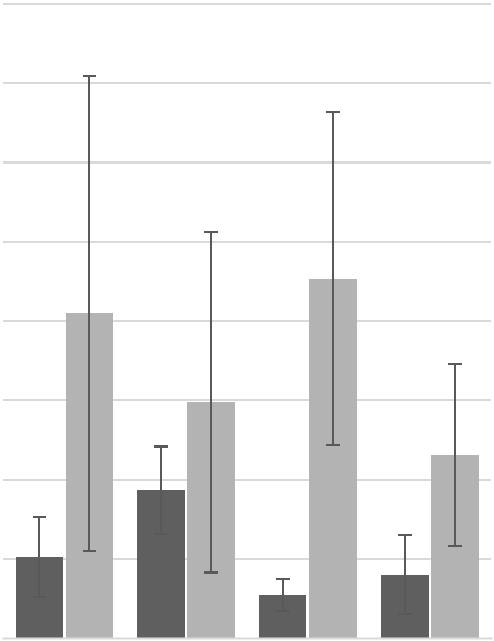
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0

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Both | Healthy | | | Unhealthy | Both |  |
|  | Proximal | Proximal | | | Proximal | Distal |  |
|  | Healthy Consumption | |  | Unhealthy Consumption | | |  |
|  |  |  |
|  |  |  |



B 160



140

120

|  |  |  |
| --- | --- | --- |
| (kCal) | 100 |  |
| Consumption |  |
| 80 |  |
|  |  |
|  | 60 |  |
|  | 40 |  |
|  | 20 |  |
|  | 0 |  |

Both Healthy Unhealthy Both

Proximal Proximal Proximal Distal

|  |  |  |  |
| --- | --- | --- | --- |
| Calories from Fruit |  | Calories from Chocolate |  |
|  |  |
|  |  |

1. *Figure 2.* Consumption of each snack type in each condition. Panel A (left) represents consumption in
2. grams, with Panel B (right) representing consumption in calories. No main effects of snack type or
3. position of either snack was found, *p*s >.273. A significant interaction between snack type and
4. chocolate bowl position was found, *p* = .010, with fruit consumption being higher when the chocolate
5. was at 70cm than 20cm.
6. *Secondary Outcomes (Grams):* Within the main analysis (2x2x2 ANCOVA) discussed above,
7. there were significant interactions between snack type and visual salience of fruit, *F*(1, 39) = 16.62, *p*
8. < .001, ȵ = .299, and between snack type and visual salience of chocolate, *F*(1, 39) = 4.65, *p* = .037,
9. ȵ = .107. Post hoc correlation analysis showed that overall visual salience of fruit positively
10. correlated with higher overall fruit consumption, r = .484, N = 48, *p* < .001. Further, visual salience
11. of chocolate M&M’s positively correlated with increased consumption of the chocolate, r = .344, N =

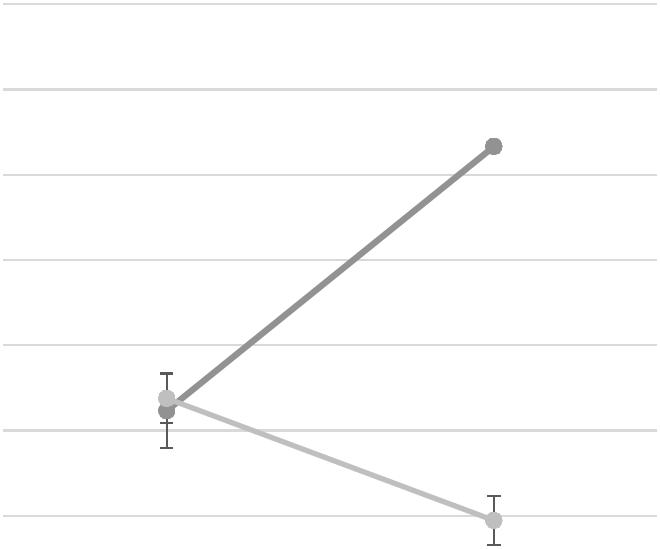
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1. 48, *p* = .017. Perceived effort did not interact with distance or consumption of either snack (Fruit *p* =
2. .497, Chocolate *p* = .196). No other significant post hoc or three way interaction were found.
3. *Secondary Outcomes (Calories):* Additional outcomes from main analysis on calorie
4. consumption showed significant interactions between snack type and fruit salience, *F*(1, 39) = 4.532,
5. *p* = .040,ȵ= .104, and snack type and chocolate snack salience, *F*(1, 39) = 4.63, *p* = .038,ȵ=
6. .106. Post hoc correlations shows that calories consumed from fruit was positively correlated with
7. higher visual salience of fruit, r = .484, N = 48, *p* < .001. Overall visual salience of chocolate was
8. positively correlated with calories consumed from chocolate, r = .344, N = 48, *p* = .017. There were
9. no significant interactions with perceived effort, *p*s > .196, or any other variable or three way
10. interaction, *p*s > .395.

|  |
| --- |
| Consumption (g) |

70



60

50

40

30

20

10

0

20 70

Chocolate Position (cm)

Fruit Chocolate

1. *Figure 3:* The interaction between fruit consumption and chocolate position illustrating how fruit
2. consumption significantly increases when the chocolate was positioned further away, *p* = .010.
3. *Sensitivity Analysis.* For sensitivity analysis, the same testing was conduct as in the main
4. analysis (2x2x2 ANCOVA). When sensitivity analysis was conducted on the 22 individuals who
5. consumed any amount of snack from both bowls (consumed fruit and chocolate in the same trial), the
6. interaction between snack type and chocolate position remained significant, *F*(1,13) = 7.01, *p* = .020,
7. ȵ = .350, with the same trend as in main analysis. The interactions between visual salience and
8. snack consumption were no longer significant, *ps* >. 054, with no other significant main effects or
9. interactions.
10. Further, when participants who moved the bowls (previously excluded) were included in
11. analysis (N = 56), the interaction between snack type and chocolate position remained significant,

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1. *F*(1, 47) = 4.768, *p* = .034,ȵ= .092. Moreover, the secondary interactions between salience and
2. snack type remained significant, snack type and visual salience of fruit, *F*(1,47) = 17.48, *p* < .001, ȵ
3. = .271; snack type and visual salience of chocolate, F(1, 47) = 6.595, *p* = .013, ȵ = .123, both in the
4. same direction as in the main analysis. These show that the results of the main analysis are robust to
5. the inclusion of individuals who moved bowls, and inclusion of only those who consumed snacks
6. from both bowls.
7. As in the main analysis, sensitivity analysis was repeated with calories consumed. Post hoc
8. power analysis (*d* = .61, α = .05, β = .80, df = 1) suggested that the study would require N = 86
9. participants to be powered for difference in calorie consumption. The difference in required sample
10. size (weight vs calories) is largely due to the increased variability of measuring calories consumed
11. compared to measuring grams. When the ANCOVA was conducted on the 22 individuals who
12. consumed from both bowls, all analysis was non-significant, all *p*s >.164. When sensitivity analysis
13. with all individuals (N = 56) was conducted on calories consumed, no main effects were found, *p*s <
14. .680. A significant interaction between snack type and chocolate bowl position was once again found,
15. *F*(1, 47) = 4.364, *p* = .042,ȵ=.085. Interactions between visual salience and snack type were found,
16. *p*s < .034, with the same directions as in main analysis. The sensitivity analysis on calorie
17. consumption suggests that the results may be sensitive to inclusion of individuals who moved the
18. snacks closer to themselves, and shows no traditional proximity effect.

|  |  |
| --- | --- |
|  | ACCEPTED MANUSCRIPT |
| 363 | **Discussion** |
| 364 | No traditional proximity effect was found for either snack type, and thus failing to support |



1. hypotheses H1 and H2. Rather, The results show that a greater quantity of a fruit was consumed when
2. the chocolate snack was placed further away than the fruit, illustrating that consumption of the
3. healthier fruit may be contingent on the position of another, unhealthier snack (chocolate), and
4. accepting hypothesis H3. This displays a “relative” proximity effect, where the consumption of one
5. snack was reliant on the position of a second snack, in this case fruit consumption being reliant on
6. chocolate position. Interestingly, chocolate consumption was unaffected by the fruit position. The
7. study also suggests that snack consumption is largely influenced by the visual salience of each snack,
8. with more of each snack type (fruit and chocolate) being consumed by those who rated the snack as
9. being more highly salient, despite mean salience ratings being similar across conditions. While
10. individuals perceived more effort to be required to attain a snack from further away, this had no
11. relationship with actual snack consumption. Although the study was not powered to detect differences
12. in calorie consumption, findings were similar when calorie consumption was analysed. The
13. interaction between fruit consumption and chocolate position approached significance, and higher
14. visual salience of each snack correlated with more calories of the corresponding snack being
15. consumed.
16. The main finding of a relative proximity effect is novel and brings in to question how the
17. proximity effect should be considered in future studies. Previous studies and reviews have defined the
18. proximity effect as when “foods that are more proxi mate, or closer to the individual, are consumed in
19. greater quantities” (Privitera & Zuraikat, 2014, pa ge 175), and as “variations in the distance of food
20. placement relative to consumers within microenvironments” (Bucher et al, 2016, page 2). However,
21. these definitions do not adequately apply to the results found in the present study. In the current study,
22. the snack that was “more proximate, or closer to th e individual” was not “consumed in greater
23. quantities” as a result of its own position, nor wa s it solely “variations in the distance of food
24. placement relative to the consumer” which influence d consumption. Instead, the results of the present
25. study show that the snack being consumed was influenced by the *relative* distance of another snack.
26. Therefore, the findings of the current study suggest that there may be a *relative* proximity effect to
27. define the difference in consumption due to the position of snacks relative to both the consumer and
28. other snacks, in addition to the previously defined, traditional proximity effect (Bucher et al., 2016).
29. A relative proximity effect can be seen in most real world food settings, where different foods are
30. commonly presented together and so is perhaps a more ecologically valid environment.
31. The previous findings of Privitera and Zuraikat (2014) found a proximity effect regardless of
32. snack preference, as individuals in their study consumed more apple slices when closer, despite
33. showing preferences for popcorn. The findings of the present study are similar, as individuals

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1. consumed a larger amount of fruit when proximal despite preferring chocolate which was placed
2. slightly further away. Taken together, both studies seem to suggest that the proximity effect is
3. somewhat independent of food preference, and can increase consumption of lesser-preferred, healthier
4. snacks if the preferred unhealthier snacks are presented further away. The present study differs from
5. that of Privitera and Zuraikat (2014) in that the presents study found healthy snack (fruit)
6. consumption to depend on the relative position of the unhealthy snack, rather than its own absolute
7. position, as stated with the traditional proximity effect. This difference may be due to the distances
8. used, as Privitera compared consumption from 30cm and 2m, thus requiring the participant to exert
9. more effort by standing and walking to attain distal snacks. Privitera and Zuraikat’s (2014) study did
10. not measure perceived effort, and so it is unknown whether individuals consumed less of the distal
11. food due to their perception of requiring too much effort. Participants in the present study stated that
12. attaining a snack from 70cm required significantly more effort than attaining from 20cm, but no
13. moderating effect of effort on consumption was found.
14. A recent naturalistic study by Kroese, Marchiori, and De Ridder, (2016) found that
15. positioning healthy snacks close to the checkout increased healthy snack sales, but found the re-
16. positioning of healthy snacks had no significant impact on unhealthy snack sales. This finding
17. illustrates a similar effect to that found in the current study, in that healthy snack sales were higher
18. when unhealthy snacks were relatively further away than healthy snacks. Notably, Kroese and
19. colleagues (2016) measured snack sales and not actual consumption, but both studies indicate
20. presence of a relative proximity effect in both laboratory and field settings. Further, recent laboratory
21. findings from Hunter et al. (2018) found no proximity effect in study 1, but found a small proximity
22. effect in their second study. The studies by Hunter and colleagues suggested that the proximity effect
23. is unlikely to rely on cognitive resources, and that very few participants were aware of the true intent
24. of the study. Similarly, very few participants in the present study were aware of the true measures of
25. the study, yet a proximity effect of sorts was present.
26. Hollands, Marteau, and Fletcher (2016) recently proposed a conceptual framework to further
27. understand non-conscious processes in health behaviours, stating that in order for a behaviour to be
28. non-conscious, the individual must either be unaware of making the behaviour, unaware of the
29. stimulus influencing behaviour, or the causal link between the two. While the present study and study
30. 1 of Hunter et al., (2018) did not find a conventional proximity effect, both indicate that participants
31. were generally unaware of the distance of snack influencing their behaviour, suggesting that the
32. proximity effect does indeed occur through manipulation of non-conscious mechanisms. Future
33. proximity studies may aim to explore parameters which the proximity effect occurs under, and to
34. further examine the awareness of participants in accordance with Hollands et al., (2016). Studies may
35. administer a funnelled debrief or a similar approach in order to ascertain participant’s level of
36. awareness, which could then be included in analysis.

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434 The study hypothesised that the proximity effect would be moderated by either visual salience

1. or perceived effort, or an interaction between the two mechanisms. The present study found that
2. visual salience moderated consumption of both fruit and chocolate, with higher self-reported visual
3. salience scores relating to an overall higher consumption of each. However, visual salience did not
4. interact with the proximity of either snack, as when explored at a condition-level, visual salience of
5. the fruit was associated with higher fruit consumption in the ‘ *both proximal’* and ‘*chocolate proximal*’
6. conditions, but not associated with higher consumption in either the ‘ *healthy proximal’* or ‘ *both*
7. *distal’* conditions. The visual salience of chocolate was only associated with higher consumption in
8. the *‘both distal’* condition, with no association with the remaining three conditions. Moreover, the
9. visual salience interaction was no longer significant when only those who had consumed from both
10. bowls were analysed. These associations may indicate that visual salience is independent to the
11. proximity effect, and may influence consumption regardless of proximity.
12. Research from Painter and colleagues (2002, Wansink et al., 2006) has previously suggested
13. that snack consumption is higher when snacks are more visible. However, Wansink et al., (2006) uses
14. the term ‘salience’, despite the stimuli in the stu dy relating more to visibility than to salience. More
15. recent research from Maas et al., (2012) also refers to visual salience rather than visibility, but uses a
16. short scale to measure visual salience more efficiently than Wansink. Hence, future studies should
17. build on the work by Maas and colleagues rather than that of Wansink and colleagues in terms of
18. visual salience. While the present study adds evidence for the role of visual salience on consumption
19. in these paradigms, future studies that directly manipulate visual salience to determine its role within
20. the proximity effect would be highly valuable. In relation to perceived effort, Maas et al., (2012)
21. suggested that perceived effort influenced consumption, but was not entered as a covariate into
22. analysis so cannot be certain on a potential interaction between effort, proximity, and consumption.
23. Both the present study, Hunter et al. (2018), and that of Maas and colleagues found that participants
24. perceived it to require more effort to attain the distal bowl than proximal bowl, yet the present study
25. indicates that this difference in perceived effort does not influence actual consumption. Future
26. research by the present authors will seek to directly investigate the role of effort in the proximity
27. effect (Knowles, Brown, & Aldrovandi, 2018) to clarify the aforementioned assertion of Maas et al.
28. (2012) and further the understanding of the mechanisms influencing the proximity effect.
29. To the researcher’s knowledge, this is the second study to explore the proximity effect in a
30. competitive environment, and the first to do so with both distances within arm’s reach for most
31. participants (20cm and 70cm), as opposed to larger differences in distance (30cm vs 200cm). It also
32. sought to determine whether perceptions of effort and salience had a significant role in any
33. demonstrated effects. Use of shorter distances is important, as standing and walking to attain a snack
34. requires much more effort and allows time to re-evaluate whether one wants to consume the snack
35. (Wansink, Painter, & Lee, 2006). This is a potentially confounding decision which is not present

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1. when attaining the proximal snack in the study by Privitera and Zuraikat (2014). In the present study,
2. participants did not have this extra moment to consider their actions as both distances were attainable
3. whilst seated, thus removing the added time to contemplate eating the snacks. In practical terms, the
4. results of this study illustrate that when a person is standing in front of a selection of snacks, such as
5. at a buffet table, they are likely to consume more healthy snacks when the snacks are placed closer to
6. the consumer, with the unhealthy food being placed further away relative to the healthy snack. This
7. opposes the traditional proximity effect, which suggests that a snack will be consumed more solely
8. when it is closer, regardless of the position of other snacks. It is this relative placement which the
9. study suggests influences snack selection in a competitive environment. Moreover, the results of the
10. study also suggest that when the foods are more visually salient to the consumer, consumption is
11. likely to be higher. Therefore, if foods are made to look more visually attractive and salient,
12. consumption will likely be higher than if the foods are made to look visually plain.
13. **Limitations**
14. Initially, power analysis to detect differences in consumption based on grams of each snack
15. was considered, with the study being powered for such effects. The study was not designed to detect
16. differences with calories consumed, or explore relationships involving characteristic variables such as
17. BMI. A larger sample would likely have enabled the study to detect differences in both calorie
18. consumption and detect additional covariates. However, Maas et al. (2012) found no relationship
19. between BMI and amount of snacks consumed, with Privitera and Zuraikat (2014) stating their
20. findings were independent of BMI. Moreover, the voluntary sampling method for the study led to a
21. high proportion of female participants in relation to similar studies. While this may be considered a
22. limitation, Maas and colleagues recruited a sample of all females in their exploration of the proximity
23. effect, yet found strong proximity effects in both studies. Further, Privitera and Zuraikat (2014) found
24. no moderation effect of sex on the proximity effect, and so the study is likely to be unaffected by the
25. large proportion of female participants. Also, due to the recruitment location being in a university, the
26. mean age of the sample is not representative of the general population, and so the results of the study
27. may not be fully extrapolated to other age ranges.
28. Further, the results of the current study may be largely influenced by the difference in weight
29. between one unit of M&M’s (1 gram), and one unit of fruit (between 4 grams and 8 grams depending
30. on size and fruit type). While the same weight in total was presented to participants (250g +/- .5g), the
31. bowl of chocolate M&M’s contained around 250 units or individual M&M’s. In contrast, the fruit
32. bowl contained around 35-60 units dependant on the size of fruit portion. Future competitive
33. environment studies may benefit from using snacks which differ in energy density and/or healthiness,
34. but have similar unit size and weight, in order to conduct analysis at weight, unit, and energy density
35. levels. One initial suggestion from the authors would be to use larger round chocolates, such as Lindt

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1. Lindor ® chocolates, and similar sized red grapes, as the physical characteristics of the two are
2. similar, with energy density being different. Further, the study was not powered to detect differences
3. in calorie consumption based on the interaction between chocolate position and fruit consumption of
4. the present study, which suggested a sample of 86 participants. Future studies will aim to be powered
5. for both measuring consumption in grams and calories.
6. In keeping with the initial study protocol produced for the study (Knowles et al., 2017),
7. likelihood of consumption was not analysed. Future pre-registered studies from the current authors
8. will measure consumption at both at total consumption (g/kCal), as well as likelihood of consumption
9. levels to measure both outcomes with larger sample sizes (Knowles et al., 2018). Despite not
10. measuring consumption at both the actual and likelihood levels, sensitivity analysis was conducted
11. with only those participants who consumed any amount of snack from both bowls (N = 22), with the
12. results being similar to that of the main analysis. Also, the measures included in the questionnaire
13. could be improved in future studies, in particular the physical effort scale, as measuring retrospective
14. effort with questionnaire items without also directly manipulating effort level may not be an accurate
15. representation of physical effort. Further, the study questionnaire asked participants how much they
16. liked a small range of snacks including chocolate, apples, and oranges, but participants were not asked
17. about their liking of grapes. This flaw in the questionnaire meant that not all four types of snack
18. (chocolate, apple, orange, grapes) had participant liking scores, and so the study may have been
19. improved if such results were collected. These limitation have been considered in the future study
20. exploring the role of effort within the proximity effect (Knowles et al., 2018).
21. **Conclusion**
22. Overall, the results of the current study illustrate that consumption of fruit can be reliant on
23. the positon of a separate, unhealthy snack, rather than its own absolute positon as suggested by the
24. traditional proximity effect. It calls into question the definition of a traditional “proximity effect ”, and
25. suggests that there may be *absolute* and *relative* proximity effects which occur in different
26. environments. The health implications arising from this study suggest that choice architects may be
27. able to reduce unhealthy snack consumption and increase healthy snack consumption by exploiting an
28. interaction between the relative positions of each snack to each other. Whereas previous studies
29. exploring the traditional proximity effect may suggest simply placing heathy foods close to a
30. consumer will increase the consumption of the healthy food (Rozin et al., 2011, Privitera & Zuraikat,
31. 2013), the present study suggests that this may be most effective if unhealthy options are also placed
32. further away than the healthy option. Considering this interaction between snack positions may be key
33. to re-designing the layouts of cafés and supermarkets, rather than placing one food type further away
34. or closer in isolation. The present findings suggest the food micro-environment as a whole must be
35. considered when redesigning the choice architecture with position being relative to other food items,

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1. rather than items in isolation. In doing so, this may increase consumption of the healthy item, but also
2. decrease the selection of the unhealthy item in order to extenuate selection of healthy items.

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2. Daniel Knowles (DK) is a PhD student under the supervision of Dr. Kyle Brown (KB) and Dr. Silvio
3. Aldrovandi (SA). KB and SA are Senior Lecturers of Applied Psychology at Birmingham City
4. University. DK planned the study, with revisions and feedback provided by KB and SA. The study
5. was carried out by DK, with the manuscript drafted by DK under the supervision and feedback of KB
6. and SA. Data analysis was carried out by DK. All authors have read and approved the final version of
7. the manuscript. This study was ethically approved by Birmingham City University Ethics Committee
8. under the reference 063.17. Informed consent was attained from participants prior to each trial, with
9. all data being kept anonymous and stored securely. The authors declare they have no competing
10. interests. The first author (DK) is funded as PhD student at Birmingham City University. The
11. Doctoral Research College had no part in designing the study, collecting or analysing data, or
12. preparing the manuscript. This research did not receive any specific external grant from funding
13. agencies in the public, commercial, or not-for-profit sectors

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**References**

Baskin, E., Gorlin, M., Chance, Z., Novemsky, N., Dhar, R., Huskey, K., & Hatzis, M. (2016). Proximity of snacks to beverages increases food consumption in the workplace: A field study. *Appetite*, *103*, 244–248. https://doi.org/10.1016/j.appet.2016.04. 025

Bucher, T., Collins, C., Rollo, M. E., McCaffrey, T. A., De Vlieger, N., Van der Bend, D., … Perez-Cueto, F. J. A. (2016). Nudging consumers towards healthier choices: a systematic review of positional influences on food choice. *The British Journal of Nutrition*, *115*(12). https://doi.org/10.1017/S0007114516001653

Di Cesare, M., Bentham, J., Stevens, G. A., Zhou, B., Danaei, G., Lu, Y., … Cisneros, J. Z. (2016). Trends in adult body-mass index in 200 countries from 1975 to 2014: A pooled analysis of 1698 population-based measurement studies with 19.2 million participants. *The Lancet*, *387*(10026), 1377–1396. https://doi.org/10.1016/S0140-6736(16)30 054-X

Hagger, M. S. (2016). Non-conscious processes and dual-process theories in health psychology. *Health Psychology Review*, *10*(4), 375–380. https://doi.org/10.1080/17437199.2016 .1244647

Hansen, P. G. (2016). The definition of nudge and libertarian paternalism: Does the hand fit the glove? *European Journal of Risk Regulation*, *7*(1), 1–41.

Hollands, G. J., Marteau, T. M., & Fletcher, P. C. (2016). Non-conscious processes in changing health- related behaviour : a conceptual analysis and framework. *Health Psychology Review*, *10*, 381–394. https://doi.org/10.1080/17437199.2015.1138 093

Hollands, G. J., Shemilt, I., Marteau, T. M., Jebb, S. A., Kelly, M. P., Nakamura, R., … Ogilvie, D. (2013). Altering micro-environments to change population health behaviour: towards an evidence base for choice architecture interventions. *BMC Public Health*, *13*(1), 1218. https://doi.org/10.1186/1471-2458-13-1218

Hunter, J. A., Hollands, G. J., Couturier, D.-L., & Marteau, T. M. (2016). Impact of altering proximity on snack food intake in individuals with high and low executive function: study protocol. *BMC* *Public Health*, *16*(1), 504–513. https://doi.org/10.1186/s12889-016-31 84-9

Hunter, J. A., Hollands, G. J., Couturier, D.-L., & Marteau, T. M. (2018). Effect of snack-food proximity on intake in general population samples with higher and lower cognitive resource. *Appetite*, *121*, 337–347. https://doi.org/10.1016/j.appet.2017.11. 101

Knowles, D., Brown, K., & Aldrovandi, S. (2017). Investigating the proximity effect within a competitive food environment : A study protocol, (September). https://doi.org/10.17605/OSF.IO/C7JWN

ACCEPTED MANUSCRIPT



Knowles, D., Brown, K. G., & Aldrovandi, S. (2018). Exploring the role of Effort within the Proximity Effect: A Study Protocol, 1–29. https://d oi.org/10.17605/OSF.IO/RMNYS

Kroese, F. M., Marchiori, D. R., & De Ridder, D. T. D. (2016). Nudging healthy food choices: A field experiment at the train station. *Journal of Public Health (United Kingdom)*, *38*(2), e133–e137. https://doi.org/10.1093/pubmed/fdv096

Langlet, B., Fagerberg, P., Glossner, A., & Ioakimidis, I. (2017). Objective quantification of the food proximity effect on grapes, chocolate and cracker consumption in a Swedish high school. A temporal analysis. *PLOS ONE*, *12*(8), e0182172. https://doi.org/10.1371/journal.pone.0182172

Lee, E. H. (2012). Review of the psychometric evidence of the perceived stress scale. *Asian Nursing* *Research*, *6*(4), 121–127. https://doi.org/10.1016/j.anr.2012.08 .004

Maas, J., de Ridder, D. T. D., de Vet, E., & de Wit, J. B. F. (2012). Do distant foods decrease intake? The effect of food accessibility on consumption. *Psychology & Health*, *27*(sup2), 59–73. https://doi.org/10.1080/08870446.2011.565341

Marteau, T. M., French, D. P., Griffin, S. J., Prevost, A. T., Sutton, S., Watkinson, C., … Hollands, G. J. (2010). Effects of communicating DNA-based disease risk estimates on risk-reducing behaviours. *Cochrane Database of Systematic Reviews*, (10). https://doi.org/10.1002/14651858.CD007275.pub2

Marteau, T. M., Hollands, G. J., & Fletcher, P. C. (2012). Changing Human Behavior to Prevent Disease: The Importance of Targeting Automatic Processes. *Science*, *337*(6101), 1492–1495. https://doi.org/10.1126/science.1226918

McKinsey Global Institute. (2014). *Overcoming obesity : An initial economic analysis Discussion* *paper*.

Meiselman, H. L., Hedderley, D., Staddon, S. L., Pierson, B. J., & Symonds, C. R. (1994). Effect of effort on meal selection and meal acceptability in a student cafeteria. *Appetite*, *23*(1), 43–55. https://doi.org/10.1006/appe.1994.1033

Ng, M., Fleming, T., Robinson, M., Thomson, B., & Graetz, N. (2014). Global, regional and national prevalence of overweight and obesity in children and adults 1980-2013: A systematic analysis. *Lancet*, *384*(9945), 766–781. https://doi.org/10.1016/S0140-6736 (14)60460-8.Global

Painter, J. E., Wansink, B., & Hieggelke, J. B. (2002). How visibility and convenience influence candy consumption. *Appetite*, *38*(3), 237–238. https://doi.org/10.1006/appe.2002.048 5

Petrescu, D. C., Hollands, G. J., Couturier, D.-L., Ng, Y.-L., & Marteau, T. M. (2016). Public acceptability in the UK and USA of nudging to reduce obesity: The example of reducing sugar-

ACCEPTED MANUSCRIPT



sweetened beverages consumption. *PLOS ONE*, *11*(6), e0155995.

https://doi.org/10.1371/journal.pone.0155995

Privitera, G. J., & Creary, H. E. (2013). Proximity and visibility of fruits and vegetables influence intake in a kitchen setting among college students. *Environment and Behavior*, *45*(7), 876–886. https://doi.org/10.1177/0013916512442892

Privitera, G. J., & Zuraikat, F. M. (2014). Proximity of foods in a competitive food environment influences consumption of a low calorie and a high calorie food. *Appetite*, *76*, 175–179. https://doi.org/10.1016/j.appet.2014.02.004

Rozin, P., Levine, E., & Stoess, C. (1991). Chocolate craving and liking. *Appetite*, *17*(3), 199–212. https://doi.org/10.1016/0195-6663(91)90022-K

Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving Decisions about Health, Wealth, and*

*Happiness*. New Haven, CT: Yale University Press.

Trope, Y., & Liberman, N. (2010). Construal-level theory of psychological distance. *Psychological* *Review*, *117*(2), 440–463. https://doi.org/10.1037/a0018963

Vanata, D. F., Ph, D., Hatch, A. M., & Depalma, G. (2011). Seating proximity in a cafeteria influences dessert consumption among college students. *International Journal of Humanities* *and Social Science*, *1*(4), 1–6.

Veale, J. F. (2014). Edinburgh Handedness Inventory–Short Form: a revised version based on confirmatory factor analysis. *Laterality: Asymmetries of Body, Brain and Cognition*, *19*(2), 164– 177.

Vlaev, I., King, D., Dolan, P., & Darzi, A. (2016). The theory and practice of “Nudging”: changing health behaviors. *Public Administration Review*, *76*(4), 550–561. https://doi.org/10.1111/puar.12564

Wansink, B., Painter, J. E., & Lee, Y.-K. (2006). The office candy dish: proximity’s influence on estimated and actual consumption. *International Journal of Obesity (2005)*, *30*(5), 871–875. https://doi.org/10.1038/sj.ijo.0803217