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How highlighted utensils influence consumption in a dark setting

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ABSTRACT

Objective: Previous research has shown that people consume less food in the dark compared to normal vision conditions. While this effect is commonly attributed to increased attention to internal cues, it could also be caused by increased difficulty to maneuver in a dark setting. This study investigated this potential alternative explanation.
Design: A 2 (dark versus normal vision setting) × 2 (highlighted versus non-highlighted utensils) between-subjects design was employed.
Main outcome measures: Perceived difficulty of maneuvering and consumption of yoghurt were assessed as main outcome measures.
Results: Participants consumed marginally less in dark compared to normal vision conditions, and experienced higher difficulty of maneuvering. Importantly, both effects were qualified by a significant interaction with highlighting, which increased consumption and reduced perceived difficulty compared to no highlights. Difficulty of maneuvering did not mediate the interactive effect of vision and highlighting on consumption.
Conclusion: Difficulty to maneuver should be considered when investigating eating behaviour under dark conditions. In line with an embodied cognition account, results also reveal the necessity of visual information for interaction with objects in the environment and imply that detail-deprived object information may be sufficient for activation of the motor system.

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Eating in the dark; embodied cognition; eating behaviour; body environment interaction; consumption; affordances

Introduction

In light of the obesity epidemic and health consequences resulting from unfavourable eating behaviours, researchers have been investigating the drivers of food consumption. One branch of investigations has specifically focused on the influence of visual factors on eating, by manipulating the visibility of food through blindfolding participants or darkening rooms. These studies have found lower consumption (Linné,

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Barkeling, Roessner, & Rooth, 2002; Renner, Sproesser, Stok, & Schupp, 2015), reduced monitoring capability (Scheibehenne, Todd, & Wansink, 2010), lower willingness to buy the food (Renner et al., 2015), less decelerated eating curves (Barkeling, Linné, Melin, & Rooth, 2003), and reduced acceptance of food (Wansink, Shimizu, Cardello, & Wright, 2012) under dark compared to normal vision conditions.

Previous research has tended to attribute slowed and reduced eating under dark conditions to an enhanced focus on internal satiety cues (Barkeling et al., 2003; Linné et al., 2002; Marx et al., 2003). An alternative explanation, however, could be that it is simply more difficult to maneuver dark consumption settings (e.g. in terms of locating food and food-related objects such as utensils, as well as in terms transporting food to the mouth). However, despite participants reporting motoric difficulties with eating in the dark (Scheibehenne et al., 2010), a systematic examination and experimental variation of how the ability to maneuver in dark conditions affects consumption has been missing. Previous research has indicated that eating behaviour is influenced by accessibility of food (Wansink, Painter, & Lee, 2006), visual information about the food consumed (Wansink, Painter, & North, 2005), as well as the degree to which it yields immediate interaction such as grasping and eating (Junghans, Evers, & de Ridder, 2013). In line with this body of research, we posit that an understanding of how the ability to maneuver in dark settings influences eating behaviour is essential to ensure a holistic interpretation of the effects of food visibility on consumption. In this study, we examine the potential influence of difficulty to maneuver in dark settings on consumption.

Embodied cognition

Embodied cognition theorists claim a strong link between object perception and motor interaction with objects (Wilson, 2002). Visually perceiving object properties provides information to the nervous system activating appropriate action patterns that allow body movements to be attuned to particular environment and object properties (Goslin, Dixon, Fischer, Cangelos, & Ellis, 2012). Gibson (1979) has termed the potential interactions exerted by objects and perceived by individuals as affordances. Any functional object in the environment exerts possibilities for interaction. As such, stairs afford to be climbed, handles afford to be grasped, chairs afford to be sat on (Warren, 1984; Warren & Whang, 1987), and food affords to be eaten. Visual object perception thus not only informs one about the specific properties of an object; it additionally provides information about potential motor interactions with that object.

A large array of studies has shown that object perception automatically activates motor interaction with the objects (Grèzes & Decerty, 2002; Grèzes, Tucker, Armony, Ellis, & Passingham, 2003; Tucker & Ellis, 1998). For example, participants asked to respond to object features such as colour with either the left or right hand will be affected by the spatial orientation of the presented object. If the spatial orientation of the objects affords interaction with the left hand, movements with this hand will be facilitated and vice versa (Bub & Masson, 2010), despite the task-irrelevance of this object feature (Tucker & Ellis, 1998). This body of research supports the embodied cognition notion that visual perception of objects in the environment facilitates interaction through the automatic activation of the motor system, especially the motor movements involved in interacting with the observed objects (Goslin et al., 2012). As such, the findings speak for the essential role of visual object perception in successfully and comfortably interacting with the environment, at least in people who have no visual impairments. Without the visual perception of objects, spatial information cannot be decoded and affordances are not perceived, implying that motor patterns for interaction are not activated, thereby hindering the visual guidance of action (Warren & Whang, 1987).

Current study

Based on this embodied cognition account, it can reasonably be expected that people experience more difficulties interacting with objects in their environment when they are not visually perceiving the objects they are interacting with, as is the case when blindfolded or in fully darkened rooms. This difficulty has indeed been reported in investigations into the effect of food visibility on eating behaviour (e.g. Scheibehenne et al., 2010). Nevertheless, the effects of maneuvering difficulty and ability to interact with the food and utensils on eating in dark situations has not been empirically investigated to this day.

Therefore, the current study attempted to replicate the effect of reduced eating in a dark situation, and additionally aimed to investigate the degree to which this effect is influenced by the ability to maneuver in dark conditions. To this end, a highlighting manipulation was included to experimentally test the effect of maneuvering on consumption. Specifically, the provision of utensils and bowls that glow in the dark in the highlighted conditions allowed us to examine the degree to which the reduction in amount of food consumed under dark conditions, compared to normal vision conditions, can be attributed to the ability to maneuver and motorically interact with the food using utensils.

It was predicted that participants in the dark condition would consume less food compared to those in the normal vision condition as shown in previous research (Hypothesis 1). However, it was also predicted that this effect should be alleviated by highlighting utensils, such that consumption should be higher in the dark highlighted condition than the dark not highlighted condition (Hypothesis 2). Moreover, it was predicted that participants in the dark condition would experience eating to be more difficult than those in the vision condition (Hypothesis 3), and that this effect would likewise be alleviated by the use of highlights (Hypothesis 4). Finally, it was hypothesised that difficulty to maneuver would mediate the effects of vision and highlighting on consumption (Hypothesis 5). These findings would suggest that decreased consumption under dark conditions is driven by an increased difficulty maneuvering in the dark.

Material and methods

Design

The study was employed a 2 (vision: dark setting versus normal vision setting) × 2 (highlights: highlighted utensils versus non-highlighted utensils) between-subjects design. The main outcome variable was the amount of yoghurt consumed by the participants. The manipulation of vision was operationalised by placing participants in a normally lit (normal vision condition) or fully dark (dark condition) room. Furthermore, each participant received either eating equipment that was highlighted by fluorescent colour which glows in the dark to ease their maneuvering while eating (highlighted utensils condition) or no such highlighted utensils (non-highlighted utensils condition). An a-priori power analysis indicated that, assuming a medium effect-size (Cohen's $f = 0.25$), a significance level of $\alpha = .05$ and a power of 0.80, a sample size of 128 participants would be necessary to be able to reliably observe an effect. The study was conducted in accordance with the ethical standards described by the Medical Research Involving Human Subjects Act (WMO, 2012), and additional ethical approval was obtained from the Ethical Committee at Utrecht University.

Pilot test of experimental manipulation

The highlighting of the utensils was done in such way that the outline of the utensils could be perceived, while the food itself remained invisible to participants. A pilot test assessed the visibility of the food under dark highlighted conditions. In this pilot test, 25 participants underwent a procedure under the same set-up as the dark highlighted condition of the main study. Participants were placed in the same dark setting, with the same highlighted utensils, and were exposed to two bowls, one with yoghurt, and one with pudding. Participants were instructed to use the provided spoons for either food, but to not actually consume any of it. Subsequent to this task they were asked about the degree to which they could see the food in either bowl (rated on a scale ranging from 1='not at all' to 7='very well'). Results showed that participants rated the visibility of both foods as very low [pudding mean (M) = 1.24, standard deviation (SD) = 0.52; yoghurt M = 1.24, SD =0.66]. On this basis, it was concluded that participants are indeed incapable of seeing the food in the dark highlighted condition.

Participants

A total of 123 participants took part in the study, nearly reaching the necessary sample size as estimated in the power analysis. The presence of several outliers on the main outcome variable of yoghurt consumption led to a violation of the assumption of normality [with a Kolmogorov–Smirnov test indicating that $D(123) = 0.116$, $p < .001$], which could render interpretation of the analyses invalid (Ghasemi & Zahediasl, 2012; Tabachnick & Fidell, 2013). To normalise the distribution of the main outcome variable, participants consuming ±2SD from the mean amount of grams of yoghurt consumed ($N = 7$) were excluded from the analyses[1], which resulted in a normal distribution of the yoghurt consumption variable [Kolmogorov–Smirnov $D(116) = 0.070$, $p = .200$]. The final sample thus consisted of $N = 116$ participants. Participants' average age was 21.7 years (SD =2.8) and 74.1% ($N = 86$) were female. BMI was provided by $N = 103$ participants who had an average BMI of 21.7 (SD =2.7).

Procedure

Two cups of different flavored yoghurt were prepared and weighed prior to participants arriving to the laboratory. Participants were recruited from a student sample for course credit or monetary rewards, and invited to participate in a taste test. Each participant provided informed consent prior to being guided to the experimental room. Those who consented to participate were randomly assigned to one of the four conditions [vision highlighted ($N = 30$), vision non-highlighted ($N = 28$), dark highlighted ($N = 29$), dark non-highlighted ($N = 29$)]. Participants were then asked to report their age, gender, current level of hunger, and any food allergies they had. In all conditions, participants were asked to sit at a table in a window-less cubicle with two cups of different yoghurts placed on a table in front of them. In the vision conditions, the lights remained switched on, whereas the lights were switched off in the dark condition, leaving the room completely dark with no source of light. Participants in the dark condition were shown manually, by guiding participants' hands to the cups, where the yoghurts and spoon were situated. All participants were instructed to eat as much as they liked but try at least a little bit from each yoghurt to be able to evaluate the taste afterwards. They were further instructed to inform the experimenter when they had completed the tasting.

After the participant completed the tasting, the experimenter took the yoghurts, switched on the lights and provided participants with a questionnaire assessing participants' perceived difficulty involved in eating, and asking participants to evaluate the yoghurts on a number of dimensions including liking and tastiness[2]. The experimenter unobtrusively weighed each cup of yoghurt again. A week after the taste test participants were sent a follow-up questionnaire via email assessing height and current weight[3].

Measures

Hunger was assessed by asking participants how hungry they currently felt, on a scale of 1 'not at all hungry' to 7 'very hungry'.

Total amount of yoghurt consumed was obtained by subtracting the weight of each cup of yoghurt after completion of the study from the weight before the start of the study, and adding the resulting amounts of both yoghurt types. As described above, to normalise the distribution of this measure, seven participants who consumed ±2SD from the mean of consumption were excluded from analyses[1].

Participants' *perceived difficulty of maneuvering* in the conditions was assessed by asking participants how difficult they found it to eat the yoghurt (1 = not at all difficult to 7 = very difficult).

Results

Descriptive statistics

Participants were, on average, not hungry at the beginning of the study, M = 3.76 (SD = 1.38). The average amount of yoghurt consumed was 64.0 g (SD = 31.3). A significant difference in consumption between genders was observed, with males eating more (M = 82.2, SD = 31.4) than females (M = 57.7, SD = 28.8), $t(114) = 3.93$; $p < .001$. Gender was therefore included as a covariate in the subsequent main analyses.

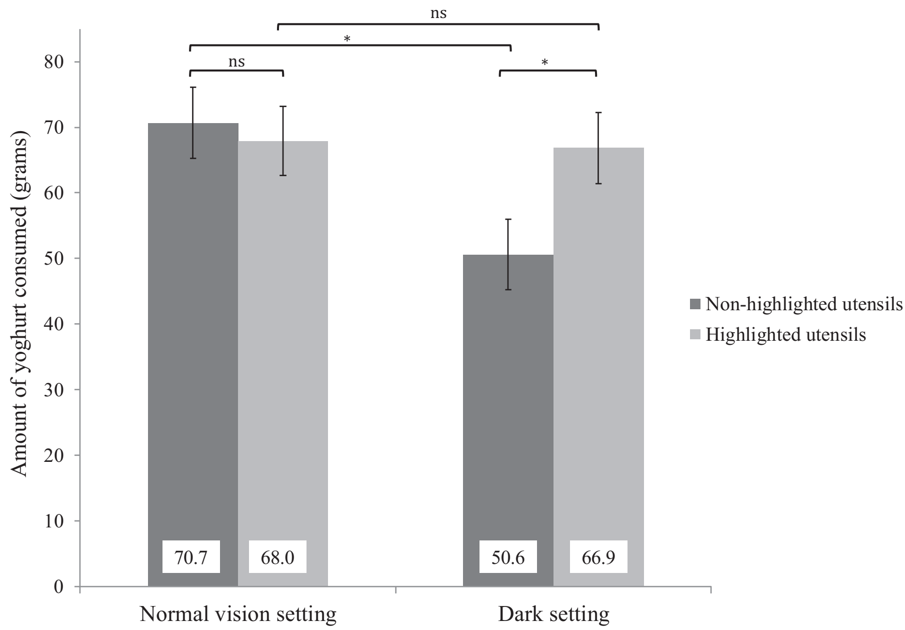

Figure 1. Effect of vision condition and highlights condition on grams of yoghurt consumed. Note: Based on estimated marginal means, corrected for gender; bars represent standard errors; * indicates statistical significance at $p<.050$; ns indicates non-significance ($p>.100$ in each case).

Randomisation check

Randomisation checks revealed no significant differences between conditions in terms of age, hunger or BMI [all F's$(3,99)<1$, all p's$>.645$], nor in terms of gender [$X^2(3,N=116)=3.44$, $p=.328$].

Amount of yoghurt consumed

A univariate ANCOVA with vision condition and highlighting condition as independent variables, consumption in grams as dependent variable, and gender as covariate was conducted to examine the first two hypotheses. Gender was a significant covariate; $F(1,111)=17.94$, $p<.001$, $\eta^2_p=0.139$, with males eating more than females. The results revealed no significant main effect of highlighting, $F(1,111)=1.57$, $p=.214$, $\eta^2_p=.014$, but a marginally significant main effect of vision was observed, $F(1,111)=3.90$, $p=.051$, $\eta^2_p=.034$. Participants in the vision condition consumed marginally significantly more grams of yoghurt [(M = 69.3, standard error of mean (SE) = 3.79] than participants in the dark condition (M = 58.7, SE = 3.78).

This effect was qualified by a marginally significant interaction between vision and highlighting, $F(1,111)=3.10$, $p=.081$; $\eta^2_p=0.027$. The interaction effect (Figure 1) was further tested using pairwise comparisons, which showed that the interaction was driven by a significant effect of highlighting on consumption in the dark setting ($p=.037$, $\eta^2_p=0.039$), with participants using highlighted utensils eating more yoghurt (M = 66.9, SE = 5.40), than those using utensils without such highlights (M = 50.6, SE = 5.38). There was no significant difference in the normal vision setting between yoghurt consumption

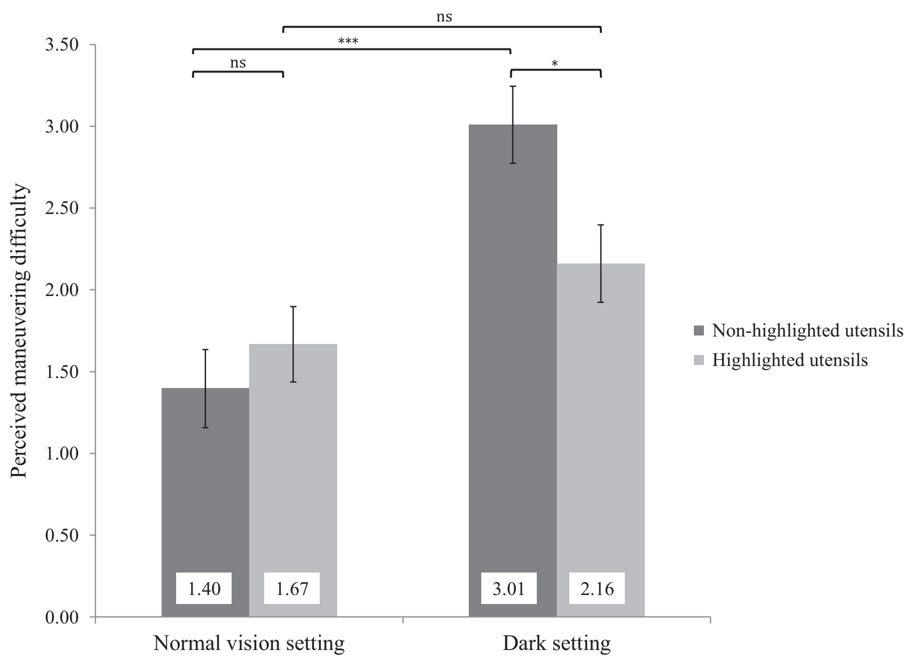

Figure 2. Effect of vision condition and highlights condition on perceived difficulty maneuvering the setting. Note: Based on estimated marginal means, corrected for gender; bars represent standard errors; * indicates statistical significance at $p<.050$; *** indicates statistical significance at $p<.001$; ns indicates non-significance ($p>.100$ in each case).

with (M = 68.0, SE = 5.26) and without (M = 70.7, SE = 5.45) highlighted utensils (p=.719, η^2_p=0.001). Interpreting the interaction in the other direction, there was no significant difference between the vision conditions in consumption of participants using highlighted utensils (p = .885, η^2_p = .000), but there was a difference between the vision conditions in consumption of participants who used non-highlighted utensils (p=.010, η^2_p=.058).

Perceived maneuvering difficulty

A univariate ANCOVA with vision condition and highlighting condition as independent variables and perceived difficulty maneuvering as dependent variable, and gender as covariate, was conducted to examine the third and fourth hypotheses. Gender was not a significant covariate; $F(1,111) < 1$, p=.713, η^2_p=.001. The results revealed no significant main effect of highlighting, $F(1,111) = 1.48$, p=.226, η^2_p=.013, but a significant main effect of vision was observed, $F(1,111) = 20.09$, $p<.001$, η^2_p=0.153. Participants in the vision condition reported lower difficulty maneuvering (M = 1.53, SE = 0.17) than participants in the dark condition (M = 2.58, SE = 0.17).

This effect was qualified by a significant interaction between vision and highlighting, $F(1,111) = 5.63$, p=.019; η^2_p=.048. The interaction effect (Figure 2) was further tested using pairwise comparisons, which showed that the interaction was driven by a significant effect of highlighting on perceived difficulty in the dark setting (p=.013, η^2_p=.054), with participants using highlighted utensils reporting lower difficulty

Table 1. Results of multiple regression analysis regressing gender, vision condition, highlighting condition, the interaction between vision and highlighting, and perceived difficulty maneuvering on amount of yoghurt consumed.

	ß	*t*	*p*
Gender	0.37	4.20	<.001
Vision	−0.29	−2.16	.033
Highlighting	−0.04	−0.32	.752
Vision × highlighting	0.25	1.60	.113
Perceived difficulty maneuvering	−0.05	−0.53	.600

Note. Adjusted model R^2=0.15, $F(5,110) = 4.97$, $p<.001$.

(M = 2.16, SE =0.24), than those using utensils without such highlights (M = 3.01, SE =0.24). There was no significant difference in the normal vision setting between perceived difficulty with (M = 1.67, SE =0.23) and without (M = 1.40, SE =0.24) highlighted utensils (p=.415, η^2_p=.006). Interpreting the interaction in the other direction, there was no significant difference between the vision conditions in the degree of maneuvering difficulty perceived by participants using highlighted utensils (p=.139, η^2_p=.020), but there was a difference between the vision conditions in the degree of maneuvering difficulty perceived by participants who used non-highlighted utensils (p<.001, η^2_p=0.173).

Mediation of the effect of vision and highlighting on consumption by maneuvering difficulty

Vision and highlighting thus influenced both consumption and perceived difficulty maneuvering; effects of highlighting were obtained on both outcome variables in the dark setting, but not in the normal vision setting. Subsequently, a mediation analysis was performed to assess whether maneuvering difficulty mediated the effect of vision and highlighting on consumption. According to Baron & Kenny's (1986) four-step procedure for mediation, the first two steps require establishing a direct effect of the causal variable(s)—in our case, vision, highlighting and their interaction, on both the outcome variable—in our case, consumption (c path) as well as on the proposed mediator—in our case, perceived difficulty (a path). The presence of both of these effects was already shown above. Step 3 requires establishing the presence of an effect of the proposed mediator on the outcome variable (b path), while controlling for the causal variable(s). To this end, amount of yoghurt consumed was regressed on difficulty of maneuvering, while controlling for vision, highlighting, and the vision-highlighting interaction (all variables were first standardised). Gender was also controlled for in this analysis. The regression analysis, reported in Table 1, showed no significant effect of perceived maneuvering difficulty on consumption when controlling for vision, highlighting, and the interaction between these two factors (ß= −.050, t= −0.53, p=.600), indicating a lack of mediation.

Using Hayes' (2013) PROCESS macro for SPSS (SPSS Inc., Chicago, IL), the indirect effect of highlighting, vision, and their interaction on consumption via maneuvering difficulty was statistically tested. Model 8 of the macro allows testing of the indirect effects of one causal factor (in our case highlighting) at each level of the other causal factor (in our case vision), and also separately tests the indirect effect of the interaction effect between both factors. Bootstrap procedures with 5000 bootstrap resamples and 95% bias-corrected bootstrap confidence intervals showed that there was no indirect effect of highlighting via perceived difficulty on consumption either in normal-vision [$B = -0.31$, CI (-2.96, 0.59)] or dark settings [$B = 0.97$, CI (-2.04, 6.70)], nor was there an indirect effect of the interaction between highlighting and vision on consumption [$B = 1.28$, CI (-2.84, 7.81)], confirming the lack of mediation already indicated by the regression analysis. It should be noted that reversing the coding, i.e. testing the indirect effects of vision at each level of highlighting, did not change any outcomes. Thus, contrary to the prediction of Hypothesis 5, maneuvering difficulty did not mediate the effects of vision and highlighting on consumption.

Discussion

The current study replicated the earlier finding that dark conditions lead to reduced consumption compared to normal vision conditions (Barkeling et al., 2003; Linné et al., 2002; Renner et al., 2015). Additionally, the findings showed that providing highlights to utensils overrode the suppressing effect of a dark setting on consumption. Moreover, results showed that participants perceived maneuvering in the dark and without highlights as more difficult than maneuvering in seeing and dark but highlighted conditions. Nevertheless, perceived difficulty of maneuvering did not mediate the effect of vision and highlighting on consumption.

Explaining reduced consumption in dark settings

Besides providing further evidence for the idea that people consume less food under dark conditions compared to normal vision conditions, this study shed light on the causes for this reduced consumption. Whereas previous research has typically attributed reduced consumption under dark conditions to, for example, increased attention to internal satiety cues, the current findings show that dark conditions also increase maneuvering difficulty, although no evidence of maneuvering difficulty driving reduced consumption was found. People perceived eating in the dark to be more difficult than eating under normal conditions. While this observation has already been made anecdotally in previous research (Scheibehenne et al., 2010) it had so far not been investigated experimentally or incorporated into the interpretation of vision effects on consumption. The current study fills this void: it has shown that highlighting those features of the environment that are required for eating, the utensils, without allowing participants to see any visual properties of the food itself, alleviated the difficulty to maneuver in dark conditions. Participants found eating in the dark to be easier when their motor interactions with the eating environment were supported by highlight.

The findings can be explained in light of previous research, which has revealed strong influences of visual qualities of food on consumption. The mere visual exposure to images of food activates brain regions involved in gustatory processing, thereby inducing expectations about taste (Simmons, Martin, and Barsalou, 2005; van der Laan, de Ridder, Viergever, & Smeets, 2011), increasing blood insulin levels that prepare the body for food consumption (Johnson & Wildman, 1983), and leading to increases in hunger and appetite thereby increasing the likelihood for consumption (Bossert-Zaudig, Laessle, Meiller, Ellgring, & Pirke, 1991; Wadhera & Capaldi-Phillips, 2014). Similarly, the observation of food is sufficient to induce salivation preparing people for eating (Spence, 2011). Via these mechanisms, seeing food can increase appetite and desire to eat, leading to higher consumption when people can see the food, compared to when they cannot. Yet, in light of the current findings, these visual qualities of food are not the sole drivers of the effect of darkness on consumption. In addition, reduced consumption in the dark can be attributed to the unfamiliar dark environment, difficulties to find the food and successfully interact with and eat it. Being blindfolded or placed in a fully dark room may distract participants from aspects of the situation they would attend to under normal vision conditions, and may require the exertion of more cognitive resources to successfully maneuver the unfamiliar environment due to lacking facilitation of automatic motor activations. Our findings show that highlighting the utensils improves the ease of maneuvering and increases consumption. However, improved ease of maneuvering did not mediate this higher consumption, suggesting that these may be two separate and unrelated processes. This lack of a mediation effect could be explained in two ways.

Firstly, one could argue that, while both difficulty to maneuver and consumption are affected by highlighting, a large driver of consumption, the tempting visual qualities of food, is not reinstalled by an improved ability to maneuver. While participants find it easier to consume the food, they may not do so to the extent they could because the external motivation for eating is lacking. Secondly, it could be that the question employed to assess difficulty to maneuver was not sufficiently precise and specific to accurately tap into the mechanism that does mediate the effect of vision and highlights on consumption. Future research should try to examine whether more elaborate assessments of difficulty to maneuver can provide a more detailed picture of the relationship.

Limitations

This study is not without limitations. Two methodological issues should be noted. Firstly, several outliers were removed to attain a normal distribution of the main outcome variable, yoghurt consumption. These outliers had a suppressing effect on the results—retaining them in the sample rendered the effects of vision and highlighting on consumption insignificant—although the pattern of results remained very similar. Removing the outliers also reduced the power of our analyses, which was not overly large to begin with (the number of participants recruited being only just sufficient to detect medium-sized effects). Replication of the current findings, especially regarding the novel effects on perceived maneuvering difficulty, is called for before firm conclusions can be drawn.

Concerning the effects on perceived maneuvering difficulty, the current study could not confirm the expected pattern of mediation. As suggested above, this could mean either that the current assessment of difficulty was not sufficiently precise to tap into the actual mediating mechanism, or that difficulty maneuvering the setting does not actually mediate the effects of vision and highlighting on consumption. A potential alternative explanation for the observed pattern on consumption could be that eating in the dark makes people uncomfortable and that this reduces amount of consumption. Highlighted utensils might alleviate this sense of uneasiness, as it allows participants to see at least something in an otherwise fully dark room[4]. Maneuvering difficulty could, in this case, be unrelated to the effects found on consumption.

Implications and suggestions for future research

Two important implications can be drawn from this study for the realm of eating behaviour. One, the findings imply that difficulty of maneuvering in a darkened environment needs to be taken into account when interpreting eating behaviour under no vision conditions. Two, the study corroborates claims from the embodied cognition literature about the importance of the interaction of mind, body, and environment in determining behaviour (Wilson, 2002). Eating behaviour appears to be driven by a combination of cognitive factors and the possibility of the body to successfully interact with the environment.

The current study also has implications beyond the realm of eating, for general behaviour and interaction between people and objects in their environments. The results provide evidence for the importance of visual information about the environment for the ease of interacting with it. Lacking visual perception implies missing information about the properties of the objects, but also that no motor systems can be activated via affordances of the objects. Relating back to eating behaviour, it could be argued that the latter is related to the increased difficult of maneuvering, whereas the former could be related to the lower consumption even under highlighted conditions. The visual properties of the food, the tempting qualities that have shown to influence peoples' consumption are lacking in the highlighted condition, which could explain the missing mediation effect. Future research is required to evince these speculations.

For the field of embodied, cognition the findings suggest that it may not be necessary to observe all aspects of objects to facilitate motor interaction. Detail-deprived information, as in the dark highlighting condition, may be sufficient to show affordance effects and facilitate interaction, at least in situations in which people are aware of what kind of objects they are perceiving. Future research should investigate the amount of detail object perception needs to entail to facilitate motor interaction.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. For consistency's sake, we removed these seven participants in all subsequent analyses, also the analyses with maneuvering difficulty as outcome variable. When these outliers were included in the main analyses, the effects of experimental condition on yoghurt consumption were no longer statistically significant (although the pattern of results remained unchanged); effects on maneuvering difficulty remained unchanged.

2. The questionnaire also assessed how many grams and calories participants thought they had consumed, and whether they felt they had overeaten. These data are not analyzed in the current study; nor are the results from the taste test, which was only included to uphold the cover story.
3. The follow-up questionnaire also assessed ideal weight and sensitivity to the food environment. These data are not analyzed in the current study.
4. We thank anonymous reviewer 1 for this suggestion.

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References

Barkeling, B., Linné, Y., Melin, E., & Rooth, P. (2003). Vision and eating behavior in obese subjects. *Obesity Research*, *11*, 130–134. doi: 10.1038/oby.2003.21

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology*, *51*, 1173–1182. doi: 10.1037/0022-3514.51.6.1173

Bossert-Zaudig, S., Laessle, R., Meiller, C., Ellgring, H., & Pirke, K. M. (1991). Hunger and appetite during visual perception of food in eating disorders. *European Psychiatry*, *6*, 237–242.

Bub, D. N. & Masson, M. E. J. (2010). Grasping beer mugs: On the dynamics of alignment induced by handled objects. *Journal of Experimental Psychology: Human Perception and Performance*, *36*, 341–358. doi: 10.1037/a0017606

Ghasemi, A., & Zahediasl, S. (2012). Normality tests for statistical analysis: A guide for non-statisticians. *International Journal of Endocrinology and Metabolism*, *10*, 486–489. doi: 10.5812/ijem.3505

Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston, MA: Houghton-Mifflin.

Goslin, J., Dizon, T., Fischer, M. H., Cangelosi, A., & Ellis, R. (2012). Electrophysiological examination of embodiment in vision and action. *Psychological Science*, *23*, 152–157. doi: 10.1177/0956797611429578

Grèzes, J. & Decety, J. (2002). Does visual perception of object afford action? Evidence from a neuroimaging study. *Neuropsychologia*, *40*, 212–222. doi: 10.1016/S0028-3932(01)00089-6

Grèzes, J., Tucker, M., Armony, J., Ellis, R., & Passingham, R. E. (2003). Objects automatically potentiate action: An fMRI study of implicit processing. *European Journal of Neuroscience*, *17*, 2735–2740. doi: 10.1046/j.1460-9568.2003.02695.x

Hayes, A.F. (2013). *Methodology in the social sciences. Introduction to mediation*, moderation*, and conditional process analysis: A regression-based approach*. New York, NY: Guilford Press.

Johnson, W. G., & Wildman, H. E. (1983). Influence of external and covert food stimuli on insulin secretion in obese and normal persons. *Behavioral Neuroscience*, 97, 1025–1028. doi: 10.1037/0735-7044.97.6.1025

Junghans, A. F., Evers, C., & de Ridder, D. T. D. (2013). Eat me if you can: Cognitive mechanisms underlying the distance effect. *Plos One*, *8*, e84643. doi: 10.1371/journal.pone.0084643

Linné, Y., Barkeling, B., Roessner, S. & Rooth, P. (2002). Vision and eating behavior. *Obesity Research*, *10*, 92–95. doi: 10.1038/oby.2002.15

Marx, E., Stephan, T., Nolte, A., Deutschländer, A., Seelos, K. C., Dieterich, M., & Brandt, T. (2003). Eye closure in darkness animates sensory systems. *NeuroImage*, *19*, 924–934. doi: 10.1016/S1053-8119(03)00150-2

Renner, B., Sproesser, G., Stok, F.M., & Schupp, H. (2015). Eating in the dark: A dissociation between perceived and actual food consumption. *Food Quality and Preference*, *40*, 145–151. doi: 10.1016/j.foodqual.2016.02.010
Scheibehenne, B., Todd, P. M., & Wansink, B. (2010). Dining in the dark: The importance of visual cues for food consumption and satiety. *Appetite*, *55*, 710–713. doi: 10.1016/j.appet.2010.08.002
Simmons, W. K., Martin, A., & Barsalou, W. (2005). Pictures of appetizing foods activate gustatory cortices for taste and reward. *Cerebral Cortex*, *15*, 1602–1608. doi: 10.1093/cercor/bhi038
Spence, C. (2011). Mouth-watering: The influence of environmental and cognitive factors on salivation and gustatory/flavor perception. *Journal of Texture Studies*, *42*, 157–171. doi: 10.1111/j.1745-4603.2011.00299.x
Tabachnick, B.G., & Fidell, L.S. (2013). *Using multivariate statistics*. (6th ed.). Boston, MA: Pearson.
Tucker, M. & Ellis, R. (1998). On the relations between seen objects and components of potential actions. *Journal of Experimental Psychology: Human Perception and Performance*, *24*, 830–846. doi: 10.1037//0096-1523.24.3.830
Van der Laan, L. N., de Ridder, D. T. D., Viergever, M. A., & Smeets, P. A. M. (2011). The first taste is always with the eyes: A meta-analysis on the neural correlate of processing visual food cues. *NeuroImage*, *55*, 296–303. doi: 10.1016/j.neuroimage.2010.11.055
Wadhera, D. & Capaldi-Phillips, E. D. (2014). A review of visual cues associated with food on food acceptance and consumption. *Eating Behaviors*, *15*, 132–143. doi: 10.1016/j.eatbeh.2013.11.003
Wansink, B., Painter, J. E., & North, J. (2005). Bottomless bowls: Why visual cues of portion size may influence intake. *Obesity Research*, *13*, 93–100. doi: 10.1038/oby.2005.12
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*, *30*, 871–875. doi: 10.1038/oby.2005.12
Wansink, B. Shimizu, M., Cardello, A. V., & Wright, A. O. (2012). Dining in the dark: How uncertainty influences food acceptance in the absence of light. *Food Quality and Preference*, *24*, 209–212. doi: 10.1038/sj.ijo.0803217
Wilson, M. (2002). Six views on embodied cognition. *Psychonomic Bulleting & Review*, *9*, 625–636. doi: 10.3758/BF03196322
Warren, W. H. (1984). Perceiving affordances: Visual guidance of stair climbing. *Journal of Experimental Psychology: Human Perception and Performance*, *10*, 683–703. doi: 10.1037/0096-1523.10.5.683
Warren, W. H. & Whang, S. (1987). Visual guidance of walking through apertures: Body-scaled information for affordances. *Journal of Experimental Psychology: Human Perception and Performance*, *13*, 371–383. doi: 10.1037/0096-1523.13.3.371
WMO. (2012). Central committee on research involving human subjects. Retrieved from http://www.ccmo.nl