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A bait we cannot avoid: Food-induced motor distractibility

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ABSTRACT

Food is so central to humans' life that keeping our mind away from it is not an easy task. Because of its strong motivational value, food cues attract our attention. However, often food is truly not relevant to our on-going activities. In the present study we investigated the distracting role that task-irrelevant foods (natural and manufactured) and food-cues play in performing goal-directed reaching movements. We explored whether spatial and temporal parameters of reaching movement were influenced by the presence of task-irrelevant stimuli (i.e., distractor effect), and whether this effect was modulated by participants' implicit and explicit ratings of food items and participants' tendency to restrain their diet. First we found that the movement trajectory veered consistently toward food items and food-related distractors. Second, we found that participants' own evaluation of natural and manufactured food played a differential predicting role of the magnitude of temporal and spatial parameters of the distractor effect induced by these types of food. We conclude that perceptual and attentional systems provide preferential access to stimuli in the environment with high significance for organisms.

1. Introduction

Food is essential for our survival. For this reason our brain is likely to be endowed with the ability to readily recognize edible items in the environment. What are the consequences of the presence of food for our behavior and action? Imagine a sunny afternoon while you are walking down a downtown street to go meeting some friends. You pass by an ice-cream stand. You are not hungry and you have no intention to buy any food, nevertheless, your attention is driven toward this food cue presented in the environment. In order to maintain your focus and reach your goal in such situation, your perceptual and attentional systems need to be able to ignore this irrelevant alluring information. Will you be able to ignore such distractions and reach 'safely' your destination? The answer is generally 'YES' but we are also aware that it is not always an easy task and that we often fail indulging in the allure of temptation (Jeffery et al., 2000) and our actions may be influenced so that you might find yourself moving toward the ice-cream stand.

Food cues are hard to resist because of their strong motivational value (Ouwehand & Papies, 2010). In fact, their simple presence leads people to direct selectively their attention toward attractive food items (Papies, Stroebe, & Aarts, 2008a). Results indicate that people have strong drives (i.e., 'wanting') and are willing to expend quite some effort to obtain food, in particular, when calories content is high (e.g., Goldfield & Epstein, 2002). Perceiving rewarding food does even more, such as triggering motor impulses to obtain and eat them that in turn facilitate consumption (Papies et al., 2008a; Veling & Aarts, 2011). Nowadays, the mass production and distribution together with the culinary developments have produced a 'toxic environment' where there is an excessive availability of food that is considered partially responsible for the increased intake of high-calories, palatable food (Hill & Peters, 1998; Wadden, Brownell, & Foster, 2002) and, in turn, for the raise in overeating and the prevalence of overweight and obesity (Ouwehand & Papies, 2010).

There are a few studies that examined approach tendencies toward food usually focusing on their potential role in overeating and deregulation of food intake (see Veenstra & de Jong, 2010). Food is all around us and often is not relevant to our primary goal, and in some cases it might even play a 'distracting role' and influence our on-going actions. Many of our behaviors and actions, in fact, are influenced by the presence of 'distracting' stimuli in our environment to which we often react automatically without much conscious deliberation (e.g., Ambron & Foroni, 2015; Moher & Song, 2013; Strack & Deutsch, 2004). This seems especially true for food stimuli due to their relevance for our survival.

The present research investigates the distracting impact of food on motor actions for the first time focusing on how food items when presented as task-irrelevant stimuli (i.e., distractors) may

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interference with ongoing goal-directed actions (i.e., reaching movements toward a target). By focusing on reaching movements we can investigate automatic default motor mechanisms that are ubiquitous in our daily life (cf. Milner, 1996) while systematically manipulating the characteristic of the stimuli (e.g., different types of food) and controlling for possible moderating variables. The information gained by this approach provides valuable insights that go beyond button pressing and reaction times that are considered a measure of processing and movement planning (Rosenbaum, 1985). In addition, this approach provides more detailed information regarding the characteristics and the nature of such effect by exploring both temporal and spatial parameters of the action and as such paralleling more complex behaviors and attitudes toward food in real life context.

1.1. Distractor effect in motor action

When reaching for an object, the presence in the close environment of an attention-grabbing visual stimulus (i.e., distractor), may influence our movement even if this stimulus is not the target of our action. This phenomenon is known as 'distractor effect' (Howard & Tipper, 1997; Welsh & Elliott, 2004) and refers to changes in spatial (i.e., movement trajectory) and/or temporal (e.g., movement time, reaction times, etc.) aspects of our movement. These changes induced by the presence of a distractor suggest that a motor response is planned not only toward the target but also toward this irrelevant stimulus. The reaching movement is the result of specific attentional mechanisms that select the motor program needed to accurately act upon a target and simultaneously maintain at a lower threshold (i.e., inhibit) the motor programs for irrelevant distractors (Allport, 1987). If, from one hand, changes in temporal and spatial parameters of the action suggest that the presence of the distractor elicits a response that competes with the response toward the target, on the other hand, the successful completion of the reaching movement demonstrates that the response toward the distractor is afterwards inhibited to complete the intended reaching of the target (Howard & Tipper, 1997; Welsh & Elliott, 2004). In this sense, the outcome of the action and the movement trajectory will depend upon the degree of activation and subsequent inhibition of the response elicited by the distractor, which may deviate from the 'ideal' reaching path by veering toward (or away from) the distractor location. The final movement trajectory is also influenced by (i) the characteristics of the stimuli, as task salient distractors are more difficult to suppress, and by (ii) subject's ability to inhibit the response toward the distractor (Tipper, Howard, & Houghton, 1998).

Young healthy adults seem to be able to inhibit the tendency to veer toward a distractor particularly when task-irrelevant (Ambron, Della Sala, & McIntosh, 2012; Welsh & Elliott, 2005). Recent investigations, however, demonstrated that also young healthy adults might be victim of the distracting role of task-irrelevant stimuli if salient for the subject (i.e., emotional expressions of co-species; Ambron & Foroni, 2015). Due to the importance of food for our survival, it is plausible that food, even when irrelevant to the current goal-oriented action, may still capture our attention and impact our actions.

Previous research (e.g., Castiello, 1996; Jervis, Bennett, Thomas, & Castiello, 1999) investigated the possible passive processing of food distractors implementing a kinematic analysis of upper limb reach-to-grasp movements to a target fruit. Based on results from multiple experiments it was concluded that irrelevant stimuli not physically immediate, or of no immediate behavioral importance, are ignored and do not produce interference. Namely, temporal aspects of the movement and grip magnitude were not affected in such situations. In general, interference effects seem to occur when covert attention is oriented to the distractor (for a review see Castiello, 1999). The reach-to-grasp paradigm implemented by Castiello (1996), however, greatly differs from the present paradigm (but see experiment 2D in Castiello, 1996). Additionally, no spatial parameters of the trajectory related to the distractor-effect were collected leaving untested whether food and food-related items can be so salient to affect movement trajectories during reaching task. The investigation on the 'distracting' effect of food calls also for a better understanding of the potential moderating role of the characteristics of the distractor (i.e., food) and of the to-be-distracted actors. We will discuss them now in turn.

1.2. Food characteristics

Nowadays, most of the food that we are exposed to and we choose from underwent some forms of transformation (e.g., cooking, preservation, preparation and aggregation). The distinction between natural food (Nf) and manufactured food (Mf) is particularly important and unexplored so far (but see Foroni, Pergola, Argiris, & Rumiati, 2013; Rumiati & Foroni, 2015; Rumiati, Foroni, Pergola, Rossi, & Silveri, 2016). This distinction is considered vital in the evolution of our species because cooking is considered an important component in the evolutionary jump to Homo erectus. Cooking, in fact, has been argued to have improved our ancestors' diet by increasing the energy gain and, in turn, the brain volume and its capacities (see Wrangham, 2009).

The second and, possibly, most investigated characteristic of food is calorie content (e.g., Frank, Laharnar, et al., 2010; Kadohisa, Verhagen, et al., 2005; Killgore, Young, et al., 2003; LaBar, Gitelman, et al., 2001; Nummenmaa et al., 2012; Simmons, Martin, et al., 2005). Energy value and palatability are in fact critical in eating choice and behavior. Brain imaging studies implementing fMRI and EEG techniques demonstrated how the human brain differentiates high calorie-content food from low calorie-content food (e.g., Killgore et al., 2003; Tang, Fellows, & Dagher, 2014; Toepel, Knebel, Hudry, le Coutre, & Murray, 2009). These studies together suggest that the food's energetic content is a reward property that is processed very rapidly by a distributed network of brain regions typically involving object categorization (occipital regions and temporo-parietal cortices), reward assessment (prefrontal cortex), evaluation of the biological relevance of a stimulus (medial and dorsolateral prefrontal cortex and the diencephalon), and decision making (inferior frontal cortices). At the behavioral level, the distinction between high-calorie palatable food and low-calorie healthier food has been investigated focusing on the social cognitive processes involved in resisting impulsive behaviors and overeating of palatable food (for a review see Hofmann, Friese, & Wiers, 2008; Papies, Stroebe, & Aarts, 2008b). These studies have often investigated special populations mostly focusing on female-only participants or on chronic dieters (i.e., retrained eaters), as these groups tend to show systematic differences in their cognitive processes and reactions to food stimuli compared to the rest of the population (Stroebe, Van Koningsbruggen, Papies, & Aarts, 2013).

These considerations highlight the need to extend the exploration of food processing to a more representative sample in which important variables (e.g., restrain eating level) are also assessed. Restrained eaters, in fact, show increased attentional biases toward food-related stimuli during cognitive tasks (Watson & Garvey, 2013) and thus, the level of diet restrain is a potential moderating variable for the present purposes. In addition, as attitude toward food, desire to eat (i.e., wanting), and healthy features of food play a role during perception of food stimuli, it would also be important to combine these assessments during the exploration of the distracting role of food in motor actions. Food preference, for instance, systematically influences approach/avoidance tendencies as measure by participants' tendency of sway toward or away a highly