Cognition and Emotion

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/pcem20

Olfactory influences on reach-to-press movements in a stop-signal task

Javier Albayay, Umberto Castiello & Valentina Parma

To cite this article: Javier Albayay, Umberto Castiello & Valentina Parma (2021): Olfactory influences on reach-to-press movements in a stop-signal task, Cognition and Emotion, DOI: 10.1080/02699931.2021.1932428

To link to this article: https://doi.org/10.1080/02699931.2021.1932428

COGNITION AND EMOTION
https://doi.org/10.1080/02699931.2021.1932428

Routledge
Taylor & Francis Group

BRIEF ARTICLE

Olfactory influences on reach-to-press movements in a stop-signal task

Javier Albayay [a], Umberto Castiello [a] and Valentina Parma [b,c]

[a]Department of General Psychology, University of Padova, Padova, Italy; [b]Department of Psychology, Temple University, Philadelphia, PA, USA; [c]Neuroscience Area, International School for Advanced Studies, Trieste, Italy

ABSTRACT

Response inhibition is sensitive to unexpected changes in the environment triggered by emotional stimuli. Whereas the impact of visual material on inhibition has been widely documented, the attention on the influence of olfactory stimuli has been neglected. Here, we examined the effect of pleasant (orange), unpleasant (trimethyloxazole), and control (clean air) odour primes in a stop-signal task. Twenty-five participants had to elicit or inhibit reach-to-press actions which allowed to examine the olfactory influences on both the planning (release phase) and the on-line control (reaching phase) of responses. Additionally, we manipulated the distance between the initial hand position and the target to be pressed (10 vs. 20 vs. 30 cm). The pleasant (vs. control) odour impaired inhibition, as reflected in slower stop-signal reaction times and higher release errors, indicating greater mobilisation of inhibitory resources by pleasant stimuli. Further, faster release responses were triggered by pleasant and unpleasant primes, supporting the idea of perceptual prioritisation of emotional (vs. non-emotional) stimuli. The olfactory manipulation did not affect the reaching phase of the responses. Instead, the distance manipulation modulated the reaching but not the release phase. These results extend the sparse literature on the influences of odour stimuli on response inhibition.

ARTICLE HISTORY
Received 12 December 2020
Revised 21 March 2021
Accepted 14 May 2021

KEYWORDS
Response inhibition; olfaction; emotional priming; reach-to-press

Humans are constantly interacting with emotional stimuli coming from different sensory modalities. Emotional stimuli receive prioritised processing over non-emotional stimuli (Kalanthroff et al., 2013) and can shape the way humans plan and execute different actions as well as the way in which they inhibit behaviours (Verbruggen & De Houwer, 2007). Response inhibition, namely the ability of restrain or stop inappropriate actions, is a core executive function typically measured by stop-signal and go/no-go paradigms. Although several studies have used both tasks interchangeably, the generalizability of results across these paradigms requires caution (Littman & Takács, 2017).

Most of the studies investigating the impact of emotional stimuli on the stop-signal task have used audiovisual material and yielded inconsistent results. Verbruggen and De Houwer (2007) found that high-arousing positive and negative (vs. neutral) pictures impair response inhibition (i.e. slower stop-signal reaction time, SSRT, which indicates less efficient inhibition). Although the authors indicated that the emotional valence had little effect on inhibition, subsequent studies have reported a plethora of effects produced on stop-signal metrics by positive and negative primes. On the one hand, studies investigating negative stimuli have reported slower (Kalanthroff et al., 2013), faster (Pawliczek et al., 2013) and equivalent (Sagaspe et al., 2011) SSRT following negative (vs. neutral) visual primes, suggesting that these effects, rather than following a simple positive–negative dimension, are instead emotion-specific (Xu et al.,

CONTACT Javier Albayay javier.albayay@gmail.com Department of General Psychology, University of Padova, Via Venezia 8, 35131, Padova, Italy

Supplemental data for this article can be accessed at https://doi.org/10.1080/02699931.2021.1932428

2016). On the other hand, studies investigating positive stimuli have found slower SSRT (Monk et al., 2017) and higher error rates (Kreusch et al., 2017) following pleasant (vs. neutral) visual primes, in line with the notion that pleasant stimuli require more inhibitory resources to be terminated (Chiu et al., 2014). However, whether stimuli from other sensory modalities would map onto the effects highlighted by visual material remains unclear.

Odours are strong triggers of emotion, yet they do not always follow the patterns tracked by visual stimuli and their implicit character makes them suitable candidates to study emotional priming (Smeets & Dijksterhuis, 2014). Additionally, there are many cases in which odours trigger failed inhibitory responses, such as increased craving following exposure to appetitive scents (Kreusch et al., 2017). Following these premises, we have recently shown that odour primes can modulate response inhibition in the go/no-go paradigm (Albayay et al., 2019). We found that pleasant odours triggered higher error rates in no-go trials as compared to when no odour was smelled. These results aligned with the assumption that pleasant stimuli trigger automatic approach tendencies and require greater mobilisation of inhibitory resources (Chiu et al., 2014).

Given the inconsistencies between go/no-go and stop-signal paradigms, in the present study, we aimed to determine whether odour primes of different valence affect response inhibition in a stop-signal task. We instructed participants to respond by releasing a starting switch and then reach and press the spacebar of a keyboard (i.e. reach-to-press). This allowed assessing the olfactory influences on both the planning and the on-line control phases of the movement (Glover, 2004). We anticipated pleasant odours to impair inhibition, as reflected in slower SSRT and higher rates of release errors in stop trials, following the premise that positively-valenced contexts increase motor excitability (Chiu et al., 2014). Further, we expected odours to facilitate response readiness (i.e. faster reaction time, RT) based on the idea that emotional (vs. non-emotional) stimuli are perceptually prioritised (Kalanthroff et al., 2013). Additionally, to further explore how reach-to-press actions behave in the stop-signal paradigm, we manipulated the distance between the starting switch and the keyboard's spacebar. We expected shorter movement time (MT) and higher rates of reaching errors at shorter distances where less time is available to implement on-line adjustments. We did not expect the distance manipulation to modulate the SSRT as it has shown to be unaffected by the demands of the go task (Logan, 2015). Regarding whether the olfactory manipulation modulates the reaching phase, we anticipated the effects to follow the same pattern as for the release phase.

Methods

Participants

Based on an *a priori* power analysis for a medium effect size ($\eta_p^2 = 0.06$) at power = 0.8 and $\alpha = 0.05$ (*F* test family, repeated measures ANOVA; G*Power; Faul et al., 2009), twenty-five healthy individuals recruited by convenience sampling participated in this study (mean age: 23.0 ± 1.5 years old, age range: 20–26 years old, 16 women). We oversampled considering the exclusion criteria related to the calculation of the SSRT (see *Statistical analyses*) based on which nine out of thirty-four initially recruited participants were excluded. For brevity, the inclusion criteria are described in the *Supplementary material*. All participants gave their written consent and were debriefed about the purpose of the study at the end of the experiment. All procedures were approved by the local Institutional Review Board (International School for Advanced Studies, Trieste, Italy) and were in compliance with the Declaration of Helsinki.

Apparatus and stimuli

Odour stimuli. Two odours diluted with propylene glycol were used in this study: orange (30% v/v, Givaudan), and 2,4,5-trimethyloxazole (0.5% v/v, Sigma-Aldrich; a burnt nutty scent). Clean air (over propylene glycol) was used as a control condition. These odours were isointense and differed in pleasantness (orange = most pleasant; trimethyloxazole = most unpleasant; see *Supplementary material*). The odours were stored in sanitised glass jars (3 mL solution glass 4 oz jars, Uline, Pleasant Prairie, WI, USA), and were presented via a customised computer-controlled olfactometer (Sniff-0, CyNexo, Udine, Italy, http://www.cynexo.com) at a flow of 3 L/min, while an air stream of 0.5 L/min remained constant throughout the experiment. Odour stimuli were delivered via cannulas covered with custom-made nose pieces, birhinally placed in the participants' nasal cavities (Albayay et al., 2019).

Visual stimuli. Go target (white circle, 2.5 × 2.5 cm), stop-signal (red circle, 2.5 × 2.5 cm), fixation point

(white cross, 1.5 × 1.5 cm) and textual information were presented on a 19″ LCD monitor (NEC AccuSync LCD93VM, 1280 × 1024, 60 Hz resolution) against a black background.

Experimental setup. Participants placed their dominant hand on a starting switch (10 × 7 cm) positioned on a 90 × 90 cm table aligned with the participant's body midline axis. A computer keyboard (30 × 10 cm) was placed at 50 cm from the edge of the table. The LCD monitor was placed at 65 cm from the edge of the table. The participants rested their head on a chin rest during the experiment. Depending on the experimental condition (see below), the switch was placed at 10, 20, or 30 cm from the keyboard's spacebar.

Procedure

Participants performed a reaching stop-signal task (e.g. Chen & Saunders, 2018) which included the presentation of odour primes. Each trial started with a black screen for 500 ms during which clean air was delivered. After this, a white fixation cross (sniff cue) appeared in the centre of the screen for 1000 ms. One of the three odour stimuli was delivered during fixation. Clean air was disabled during the presentation of the odour except during control trials. Following this, the go target was presented in the centre of the screen for 500 ms. Clean air was delivered along with the onset of the go target until the end of the trial. In stop trials, the duration of the go targets corresponded to the stop-signal delay (SSD, i.e. time in ms from the onset of the go target until the presentation of the stop-signal). Three SSDs (60, 180, and 300 ms) – selected based on a pilot aiming to determine SSDs that produce error rates higher than 15% but lower than 85% – were sampled with equal probability. The stop-signal followed the SSD in stop trials. The duration of the stop-signal was defined as 500 ms minus the duration of SSD. The screen remained black during the inter-trial interval (ITI, 1000–1200 ms). Each trial lasted on average 3100 ms (see Figure 1).

The stop-signal task was composed of six blocks. Each block included 72 trials (12 per odour stimuli) including 25% stop trials. Stop trials were presented in a pseudo-random fashion such that they were always preceded by at least one go trial. The same odour stimulus was never presented twice consecutively to avoid habituation effects. We manipulated the length of the reach-to-press action by adjusting the distance between the starting switch and the keyboard's spacebar at 10, 20, and 30 cm. Two blocks of trials were presented at each distance following a Latin square design. At the end of each experimental block, the rate of errors and mean response latencies were presented for 10 s on screen. After each block, participants rated the pleasantness and intensity of

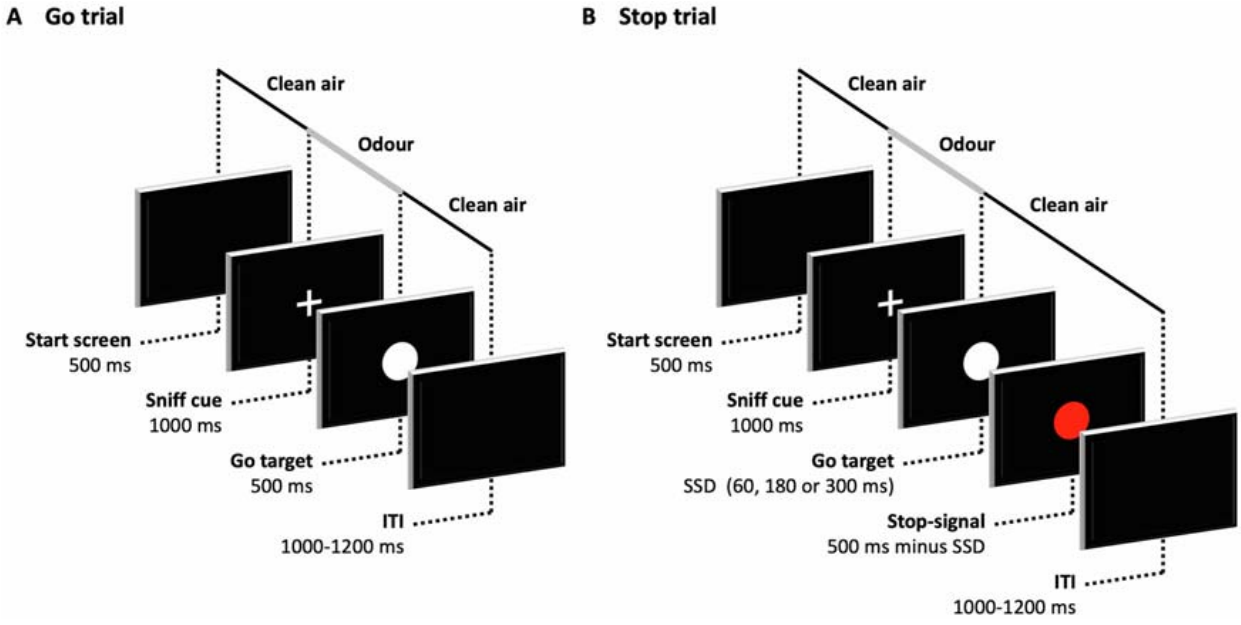

Figure 1. Graphical representation of (A) a go trial and (B) a stop trial in the stop-signal task. Clean air was delivered uninterruptedly in control trials.

each odour on visual analogue scales ranging from 0 (*not at all*) to 100 (*very much*). Participants had a one-minute rest after each rating block.

At the beginning of each trial, participants were instructed to place the ulnar side of the dominant hand on the switch with the tips of the index and the thumb touching each other. Participants were instructed to respond with a reach-to-press movement composed of an initial release phase, from presentation of go signal to release the starting switch, and a late reaching phase, from release of the switch to press the keyboard's spacebar with their index finger, unless the stop-signal was presented. After responding, participants moved their hand back to the initial position on the switch. For details on how the participants learned to breathe during the task and familiarised themselves with it, please refer to the *Supplementary material*. The experiment was carried out using the E-Prime 2.0 software and took about 60 min.

Statistical analyses

We computed the SSRT using the integration method with replacement of go omissions following the consensus guide by Verbruggen et al. (2019). The obtained SSRTs were averaged across SSDs for each experimental condition. Since the SSRT cannot be computed when the response rate in stop trials is 0% or 100% and it is unreliable if go responses are elicited in less than 90% of go trials, nine participants were removed from the final sample.

We considered the following dependent variables: SSRT, RT of correct go responses (i.e. time in ms elapsed from the onset of the go target until the participant released the switch in go trials), rate of release errors (i.e. trials in which the participants released the starting switch when the stop-signal was presented), MT of correct go responses (i.e. time in ms elapsed from the switch release until the participant pressed the spacebar in go trials), and rate of reaching errors (i.e. trials in which the participants reached and pressed the spacebar after releasing the switch in stop trials). RTs exceeding 2.5 standard deviations were excluded.

We employed mixed-effects modelling to reach enhanced statistical power for repeated-measures designs as compared to analysis of variance (Baayen et al., 2008). All models included *participants* as a random effect and the factors *valence* (control vs. pleasant vs. unpleasant) and *distance* (10 vs. 20 vs. 30 cm) as fixed effects. Nested models (e.g. a model including the factors valence and distance vs. a model including only the factor valence) were compared by means of likelihood ratio tests. We estimated the exponential of the difference between the Akaike information criterion (AIC) of the models to determine the relative likelihood of a given model [$AIC_{RL} = \exp(\Delta AIC/2)$]. The model with the statistically lowest AIC was considered as the best fitting model (Albayay et al., 2019). Furthermore, we computed the difference between the Bayesian Information Criterion (ΔBIC) of nested models; the higher the ΔBIC the more likely a given model is in comparison to the alternative model (Canale et al., 2017). We estimated the marginal and conditional R^2 to account for the proportion of variance explained by the fixed effects (R^2_m) and by both the fixed and random effects (R^3_c), respectively. We carried out multiple comparisons selecting the Tukey method for the adjustment of *p* values. We used RStudio (version 1.2.5042) for all our analyses.

Results

The descriptive statistics and the results of the main analyses are reported in Table 1.

Stop-signal reaction time

The SSRT was significantly modulated by odour valence whereas neither the main effect of distance nor the interaction valence × distance reached significance. The SSRT was slower for the pleasant odour as compared to both the unpleasant and the control odours. The unpleasant and control odours did not differ significantly (Figure 2(A)).

Reaction time

The main effect of odour valence on the RT was significant while the main effect of distance and the interaction valence × distance were not. Longer latencies were revealed for the control odour as compared to both pleasant and unpleasant odours. Instead, the pleasant and unpleasant odours did not significantly differ (Figure 2(B)).

Release errors

The rate of release errors was significantly modulated by odour valence whereas the main effect of distance

Table 1. Descriptive statistics and results of the mixed-effects modelling.

Dependent variable	Independent variable	Mean ± *SD*	Likelihood ratio test	*p*	AIC_{RL}	ΔBIC	R^2_m	R^2_c
SSRT (ms)	Valence		$\chi^2(2) = 13.161$	**0.001**	97.552	0.131	0.013	0.323
	Control	212 ± 106						
	Pleasant	238 ± 126						
	Unpleasant	209 ± 97						
	Distance		$\chi^2(2) = 0.102$	0.950	0.142	−12.927	0.001	0.309
	10 cm	221 ± 107						
	20 cm	219 ± 111						
	30 cm	219 ± 114						
	Interaction		$\chi^2(4) = 1.767$	0.779	0.044	−24.292	0.015	0.325
Go RT (ms)	Valence		$\chi^2(2) = 36.241$	**< 0.001**	> 100	18.393	0.003	0.342
	Control	394 ± 124						
	Pleasant	378 ± 120						
	Unpleasant	383 ± 120						
	Distance		$\chi^2(2) = 4.398$	0.111	1.220	−13.450	< 0.001	0.339
	10 cm	387 ± 124						
	20 cm	385 ± 121						
	30 cm	382 ± 119						
	Interaction		$\chi^2(4) = 5.762$	0.218	0.326	−29.935	0.004	0.343
Release errors (%)	Valence		$\chi^2(2) = 35.58$	**< 0.001**	> 100	19.778	0.013	0.013
	Control	48.7						
	Pleasant	62.6						
	Unpleasant	54.6						
	Distance		$\chi^2(2) = 0.787$	0.675	0.201	−15.015	< 0.001	0.001
	10 cm	56.4						
	20 cm	54.8						
	30 cm	54.6						
	Interaction		$\chi^2(4) = 1.354$	0.852	0.036	−30.250	0.014	0.014
Go MT (ms)	Valence		$\chi^2(2) = 2.156$	0.340	0.398	−15.593	< 0.001	0.483
	Control	265 ± 94						
	Pleasant	269 ± 94						
	Unpleasant	267 ± 95						
	Distance		$\chi^2(2) = 2748.7$	**< 0.001**	> 100	> 100	0.161	0.658
	10 cm	222 ± 87						
	20 cm	271 ± 89						
	30 cm	311 ± 85						
	Interaction		$\chi^2(4) = 4.099$	0.393	0.142	−31.399	0.162	0.658
Reaching errors (%)	Valence		$\chi^2(2) = 5.598$	0.061	2.224	−9.017	0.003	0.271
	Control	36.5						
	Pleasant	43.3						
	Unpleasant	37.9						
	Distance		$\chi^2(2) = 18.595$	**0.001**	> 100	3.979	0.011	0.278
	10 cm	47.2						
	20 cm	35.9						
	30 cm	35.2						
	Interaction		$\chi^2(4) = 3.610$	0.461	0.111	−25.621	0.017	0.284

Note: Bold *p* values denote statistical significance with $\alpha = 0.05$.

and the interaction valence × distance were not significant. The rate of release errors was higher for the pleasant odour than for both the unpleasant and the control odours, and for the unpleasant odour as compared to the control odour (Figure 2(C)).

Movement time

A significant main effect of distance was retrieved on the MT, while neither the main effect of odour valence (Figure 2(D)) nor the interaction valence × distance reached significance. Faster MTs were revealed for the 10 cm condition as compared to both the 20 cm ($p < 0.001$) and the 30 cm ($p < 0.001$) conditions, and for the 20 cm vs. the 30 cm condition ($p < 0.001$).

Reaching errors

Distance modulated significantly the rate of reaching errors. Instead, the main effect of odour valence just tended to be significant and the interaction valence × distance was not significant. Reaching actions were harder to cancel in the 10 cm condition as compared to both the 20 cm ($p < 0.001$) and the 30 cm ($p <$

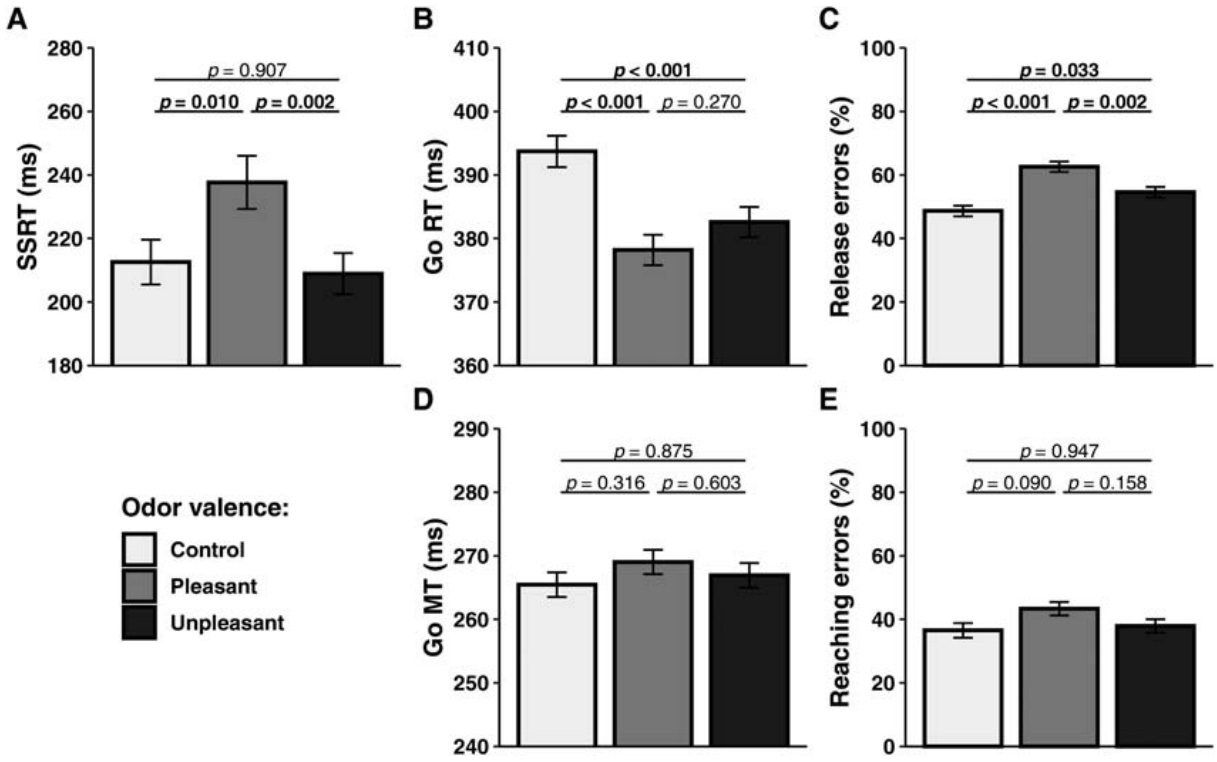

Figure 2. (A) Stop-signal reaction time, (B) reaction time of correct go responses, (C) rate of release errors, (D) movement time of correct go responses, and (E) rate of reaching errors per odour valence. Bold *p* values denote statistical significance with $\alpha = 0.05$. Error bars represent standard error of the mean.

0.001) conditions. The 20 cm and the 30 cm conditions did not differ significantly ($p = 0.991$). Multiple comparisons – aiming to explore the marginal effect of valence – revealed no significant differences by odour valence (Figure 2(E)).

Discussion

To assess the influence of task-irrelevant emotional contexts on response inhibition, induced via olfactory stimuli, we examined the effect of pleasant and unpleasant odour primes in a stop-signal task where participants had to elicit or inhibit reach-to-press responses. Moreover, we explored how varying the distance between the initial hand position and the target to be pressed would modulate the inhibition of reach-to-press actions.

When smelling the pleasant odour participants showed slower SSRT and performed more release errors. Release errors also increased following the presentation of the unpleasant odour, but not no odour. Response readiness was also modulated by the odour primes, as reflected in faster release responses, though odour valence did not affect it. No odour effect on the reaching phase of the responses emerged. Instead, the manipulation of the distance between the initial hand position and the to-be-pressed target did modulate the performance during the reaching (but not the release) phase.

Emotional stimuli in the stop-signal task are assumed to interfere with response inhibition due to an automatic capture of attentional resources from ongoing activities. When tested using visual task-irrelevant stimuli, it has been shown that such interference is triggered by high arousing stimuli regardless of their valence (Verbruggen & De Houwer, 2007). However, previous findings suggest that emotional valence plays a major role in the modulation of response inhibition by odour primes. Indeed, our result of prolonged SSRT following the presentation of the pleasant odour is in line with previous findings in the go/no-go task (Albayay et al., 2019). Thus, the idea of greater mobilisation of inhibitory resources due to an increase of motor excitability by pleasant stimuli (Chiu et al., 2014) can be extended to the stop-signal paradigm. These results only partially align with previous findings on the influence of visual emotional stimuli in the stop-signal task. Appetitive alcohol-related (vs. non-appetitive) visual stimuli have shown to interfere with response inhibition in

the stop-signal as reflected in longer SSRT (Monk et al., 2017) and higher error rates in stop trials (Kreusch et al., 2017). In this study, the pleasant odour elicited the highest response rate in stop trials, indicating that responses were less likely to be inhibited in positively-valenced contexts. Following Monk et al. (2017), the impairment of response inhibition is not restricted to alcohol-related stimuli, as comparable effects were elicited by non-alcoholic appetitive cues. The present results corroborate and extend these findings to the olfactory domain, suggesting that pleasant stimuli impair response inhibition as measured via the stop-signal task.

We also demonstrate that odour stimuli facilitated response readiness, as reflected in faster RT as compared to the control condition. Previous findings using visual stimuli have yielded inconsistent results regarding response readiness in the stop-signal task, as reflected in facilitatory (Monk et al., 2017), interference (Verbruggen & De Houwer, 2007), and null (Pawliczek et al., 2013) effects. The present results partially agree with those obtained with the olfactory go/no-go task (Albayay et al., 2019). The fact that both pleasant and unpleasant stimuli triggered faster responses supports the hypothesis of perceptual prioritisation of emotionally-valenced stimuli over non-emotional stimuli (Kalanthroff et al., 2013). However, the pleasant odour did not trigger faster responses as compared to the unpleasant odour. It is possible that specific task parameters are responsible for the lack of such effect. For instance, Albayay et al. (2019) showed that the RT was affected by odour valence only in fast-paced go/no-go tasks. As the structure of the go trials in the go/no-go and stop-signal tasks is essentially the same, we suggest that the slower pace of the stop-signal task as compared to the fast-paced go/no-go task yielded to lower cognitive load and motivation pressure which in turn resulted in equivalent RT for pleasant and unpleasant odours.

The manipulation of the distance between the initial hand position and the target to be pressed did not modulate the release phase of the responses. We anticipated this manipulation not to modulate the latency of response inhibition under the assumption that the demands of the go task do not modulate the SSRT (Logan, 2015). The SSRT can be conceptualised as a temporal point beyond which responses cannot be inhibited. This point-of-no-return is embedded in the stage of response execution (Sternberg, 1969). Our results are in line with the assumption that those experimental manipulations increasing the duration of the stages concerned with the go process after the point-of-no-return should have no effect on the SSRT (Logan, 2015). Conversely, the distance manipulation did affect the reaching phase as reflected in slower MT and more reaching errors at shorter distances (10 vs. 20 and 30 cm). This pattern of results was expected as the participants had more time to implement online adjustments – such as slowing down or cancelling underway actions – when the distance was greater. Nevertheless, the olfactory manipulation did not affect the reaching phase performance. This seems to suggest that odours only have an effect on response inhibition at the early release phase of reach-to-press actions, but not during the reaching phase even after the point-of-no-return as reflected in equivalent MT and rates of reaching errors across odour conditions.

Overall, emotional contexts induced via odour primes modulate the inhibition of reach-to-press actions. Future research is required to account for olfactory influences in other response inhibition constructs and paradigms (e.g. attentional inhibition in conflict tasks), although previous evidence suggests that odours affect motor rather than cognitive aspects of inhibition (Albayay et al., 2019). Furthermore, whether odours would impact inhibitory performance when presented as task-relevant is still unknown.

Acknowledgements

We thank the SISSA Mechatronics Lab for their technical support.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by a scholarship from the National Commission for Scientific and Technological Research (CONICYT) PFCHA/DOCTORADO BECAS CHILE/2017 [72180384] granted to J.A., and by the research programme Dipartimenti di Eccellenza (art.1, commi 314-337 legge 232/2016), which was supported by a grant from MIUR to the Department of General Psychology, University of Padova.

Data availability statement

All the datasets and R scripts to reproduce the results of this study are available in the Open Science Framework repository accessible at https://osf.io/y7hft/?view_only=e9375fd0e1c74755a212a11df7bf899d

ORCID

Javier Albayay http://orcid.org/0000-0003-2119-6316
Umberto Castiello http://orcid.org/0000-0003-0629-1286
Valentina Parma http://orcid.org/0000-0003-0276-7072

References

Albayay, J., Castiello, U., & Parma, V. (2019). Task-irrelevant odours affect both response inhibition and response readiness in fast-paced Go/No-Go task: The case of valence. *Scientific Reports*, *9*(1), 19329. https://doi.org/10.1038/s41598-019-55977-z

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*(4), 390–412. https://doi.org/10.1016/j.jml.2007.12.005

Canale, N., Rubaltelli, E., Vieno, A., Pittarello, A., & Billieux, J. (2017). Impulsivity influences betting under stress in laboratory gambling. *Scientific Reports*, *7*(1), 10668. https://doi.org/10.1038/s41598-017-10745-9

Chen, Z., & Saunders, J. A. (2018). Volitional and automatic control of the hand when reaching to grasp objects. *Journal of Experimental Psychology: Human Perception and Performance*, *44*(6), 953–972. https://doi.org/10.1037/xhp0000492

Chiu, Y. C., Cools, R., & Aron, A. R. (2014). Opposing effects of appetitive and aversive cues on go/no-go behaviour and motor excitability. *Journal of Cognitive Neuroscience*, *26*(8), 1851–1860. https://doi.org/10.1162/jocn_a_00585

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behaviour Research Methods*, *41*(4), 1149–1160. https://doi.org/10.3758/BRM.41.4.1149

Glover, S. (2004). Separate visual representations in the planning and control of action. *Behavioural and Brain Sciences*, *27*(1), 3–24. https://doi.org/10.1017/s0140525x04000020

Kalanthroff, E., Cohen, N., & Henik, A. (2013). Stop feeling: Inhibition of emotional interference following stop-signal trials. *Frontiers in Human Neuroscience*, *7*, 78. https://doi.org/10.3389/fnhum.2013.00078

Kreusch, F., Billieux, J., & Quertemont, E. (2017). Alcohol-cue exposure decreases response inhibition towards alcohol-related stimuli in detoxified alcohol-dependent patients. *Psychiatry Research*, *249*, 232–239. https://doi.org/10.1016/j.psychres.2017.01.019

Littman, R., & Takács, Á. (2017). Do all inhibitions act alike? A study of go/no-go and stop-signal paradigms. *PLOS ONE*, *12*(10), e0186774. https://doi.org/10.1371/journal.pone.0186774

Logan, G. D. (2015). The point of no return: A fundamental limit on the ability to control thought and action. *The Quarterly Journal of Experimental Psychology*, *68*(5), 833–857. https://doi.org/10.1080/17470218.2015.1008020

Monk, R. L., Qureshi, A., Pennington, C. R., & Hamlin, I. (2017). Generalised inhibitory impairment to appetitive cues: From alcoholic to non-alcoholic visual stimuli. *Drug and Alcohol Dependence*, *180*, 26–32. https://doi.org/10.1016/j.drugalcdep.2017.07.038

Pawliczek, C. M., Derntl, B., Kellermann, T., Kohn, N., Gur, R. C., & Habel, U. (2013). Inhibitory control and trait aggression: Neural and behavioural insights using the emotional stop signal task. *Neuroimage*, *79*, 264–274. https://doi.org/10.1016/j.neuroimage.2013.04.104

Sagaspe, P., Schwartz, S., & Vuilleumier, P. (2011). Fear and stop: A role for the amygdala in motor inhibition by emotional signals. *Neuroimage*, *55*(4), 1825–1835. https://doi.org/10.1016/j.neuroimage.2011.01.027

Smeets, M. A., & Dijksterhuis, G. B. (2014). Smelly primes – when olfactory primes do or do not work. *Frontiers in Psychology*, *5*, 96. https://doi.org/10.3389/fpsyg.2014.00096

Sternberg, S. (1969). The discovery of processing stages: Extensions of Donders' method. *Acta Psychologica*, *30*, 276–315. https://doi.org/10.1016/0001-6918(69)90055-9

Verbruggen, F., Aron, A. R., Band, G. P. H., Beste, C., Bissett, P. G., Brockett, A. T., Brown, J. W., Chamberlain, S. R., Chambers, C. D., Colonius, H., Colzato, L. S., Corneil, B. D., Coxon, J. P., Dupuis, A., Eagle, D. M., Garavan, H., Greenhouse, I., Heathcote, A., Huster, R. J., … Boehler, C. N. (2019). A consensus guide to capturing the ability to inhibit actions and impulsive behaviours in the stop-signal task. *eLife*, *8*, e46323. https://doi.org/10.7554/eLife.46323

Verbruggen, F., & De Houwer, J. (2007). Do emotional stimuli interfere with response inhibition? Evidence from the stop signal paradigm. *Cognition & Emotion*, *21*(2), 391–403. https://doi.org/10.1080/02699930600625081

Xu, M., Li, Z., Fan, L., Sun, L., Ding, C., Li, L., & Yang, D. (2016). Dissociable effects of fear and disgust in proactive and reactive inhibition. *Motivation and Emotion*, *40*(2), 334–342. https://doi.org/10.1007/s11031-015-9531-9