Multisensory Relationships Between Pleasantness and Softness

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Abstract - Presently, there is extensive evidence of multisensory integration in tactile and visual processing. While it has been shown that the multisensory interaction between touch and vision can influence object recognition, the role of this multisensory interaction in the affective domain is still poorly understood. The aim of this study was to examine the influence of tactile softness perception on affective processing of stimuli presented through vision.

Adapting the affective priming paradigm, an experiment was conducted with urethane gels of differing compliance and visually presented words. Participants were instructed to rate the valence of the visually presented words concurrently with the presentation of urethane gels. Reaction times and response ratings were recorded for the experiment. The results indicated that participants were slower to rate the valence of soft stimuli; we posit that the soft material disrupted the participants' attention.

We propose a second experiment to clarify whether this effect is unique only to affective ratings or whether it extends to the semantic ratings of visually presented words as well. Both experiments differ only in the instructions given – the second experiment will ask participants to rate the level of abstractness of the visually presented words instead.

Keywords – multisensory integration, words valence, tactile perception, vision, touch

INTRODUCTION

In our daily lives, we tend to think of our senses as distinct modalities that individually provide for our perception of the things around us. However, we often disregard how our senses work together to enhance our perceptions and how important this integration is in our daily lives (Stein, 2012). Consider going to the store to purchase a brand-new mobile phone; not only is our decision to purchase influenced by our preferences and expectations, we also tend to explore the phones with our eyes (visually) and hands (tactilely) to evaluate how we might feel about owning the phone. A review conducted by Spence and Gallace (2011) suggested that perceiving pleasurable attributes in one sensory modality can affect one's overall multisensory experience of the product by biasing perceptions of pleasure from other sensory modalities. So would pleasant visual aesthetics engender pleasant feelings towards the phone by biasing our hedonic tactile perception? Perhaps, a better understanding of the different multisensory integrations/interactions will help us clarify the nature of such perceptions.

That being so, while there is a myriad of permutations that one can assess in the present study (e.g. hearing and vision), we have chosen to focus on the multisensory interaction between touch and vision. Though multisensory interactions between touch and vision have been extensively studied (see Zangaladze, Epstein, Grafton, & Sathian, 1999), to the best of our knowledge, research on these interactions in the affective domain is few and far between. Thus, the present study aims to examine how tactilely perceiving softness can influence hedonic processing in the modality of vision.

Wu et al. (2011) explored the influence of the physical handling of fabrics (visual and tactile) and the digital handling of the same fabrics (visual only) on participants' engagement and hedonic responses. They found that the prior physical handling of fabrics led to a significant increase in pleasure and engagement when the same fabrics were subsequently digitally handled.

Suzuki and Gyoba (2008) found that the repeated visual exposure to novel stimuli (mere exposure effect) increased the participants' subsequent preference for said stimuli when judged by touch (vision-to-touch condition); thus, suggesting that a cross-modal interaction between touch and vision exists in the affective system. Though the authors did not find a transfer of hedonic experience for the touch-to-vision condition, they attributed this to either the (1) blindfolding of participants during the touching condition or (2) differing sensitivities of touch and vision to affective information.

Adapting the affective priming paradigm used by Pecchinenda, Bertamini, Makin, and Ruta (2014), the present study used urethane gels of differing object compliance (soft or hard) as tactilely presented stimuli and words of varied valence (negative, neutral, or positive) as visually presented stimuli. Participants were briefly presented with the tactile stimuli and made to rate the valence of the visually presented words concurrently. Considering evidence that soft tactile stimuli can engender pleasantness (unpublished results obtained in our lab) and the finding that softness perception activates the insula, part of the brain's limbic system (Kitada et al., 2019), we expect the softness/hardness of the tactile stimuli to modulate the participants' perception of how positive the visually presented words are. Specifically, we hypothesised that (1) the presentation of soft tactile stimuli would result in more pleasant (positive) word ratings and (2) the presentation of hard tactile stimuli would result in more unpleasant (negative) word ratings. This study would also allow clarifying the aforementioned interpretations by Suzuki and Gyoba (2008) – as participants were not blindfolded in the present experiment, the validity of alternative interpretation could be assessed.

EXPERIMENT 1

PARTICIPANTS

Twenty-four (12 male and 12 female) healthy right-handed participants were recruited for Experiment 1 – via posters placed around Nanyang Technological University's campus or by word-of-mouth. In order to obtain an objective measure of the participants' handedness, the Fazio Laterality Inventory (FLI; Fazio, Dunham, Griswold, & Denney, 2013) was administered. Participants recruited had normal or corrected-to-normal vision and did not have impairments/injuries on their right hands.

The present study was approved by the local psychology ethics committee of Nanyang Technological University.

MATERIALS

Visually Presented Stimuli

A pilot study (*N* = 10) was conducted on 130 words selected from the Affective Norms for English Words (ANEW; Bradley & Lang, 1999). Each participant was presented with the set of 130 randomised words twice; participants were instructed to rate the valence of the words in the first presentation and to rate the words' degree of association with tactile sensations in the second presentation (the task order was counterbalanced across participants). The average valence and tactile association ratings were calculated for each word.

Of the 130 words, 24 words were selected to be the experiment's visually-presented stimuli (see Table 1) – eight positively valenced words (that received the highest valence ratings), eight neutrally valenced words (that received valence ratings around the average valence) and eight negatively valenced words (that received the lowest valence ratings). In addition, care was taken to ensure that all selected words had below-average tactile association ratings; this ensures that the strength of association with tactile sensations is kept constant throughout the range of word valence – preventing the introduction of potential confounds caused by words with extremely high/low tactile association ratings.

Visual stimuli of the pilot study and the experiment were presented to the participants with Neurobehavioral System's Presentation.

Table 1. Selected Visually Presented Stimuli

Positively Valenced Words	Neutrally Valenced Words	Negatively Valenced Words
Education	Blue	Death
Free	Doctor	Alone
Health	Farm	Fear
Hope	Manner	Fire
Justice	Market	Industry
Kind	Mind	Lost
Life	Power	Stress
Peace	Theory	Trouble

Tactilely Presented Stimuli

Four urethane gels (manufactured by Kato Tech, Japan) of differing object compliance were used in the experiment – A (0.13 mm/N); B (0.45 mm/N); H (7.56 mm/N); I (10.53 mm/N). The urethane gels were presented to the participants via a machine, Model SHR III-5 SK by Aikoh Engineering, Japan.

EXPERIMENTAL SETUP & PROCEDURE

Upon giving informed written consent and completing the FLI, participants were seated in front of the experiment's apparatus (see Figure 1). Participants were instructed to put on an appropriately sized fingerless glove on their right-hand (three fingertips were exposed: index, middle, and ring). The glove was then affixed to the base of the machine using Velcro.

To ensure that the participants attended only to the visually presented words to be shown on the monitor (positioned about 35 cm away), they were directed to rest their head on an ophthalmic chin rest. Participants were then briefed on the instructions ("Please, rate the words that will appear on the screen in terms of how positive they are. Use a scale from 1 to 9, with 1 = "not positive at all" and 9 = "very positive"") and reminded to direct their attention only to the monitor placed in front of them.

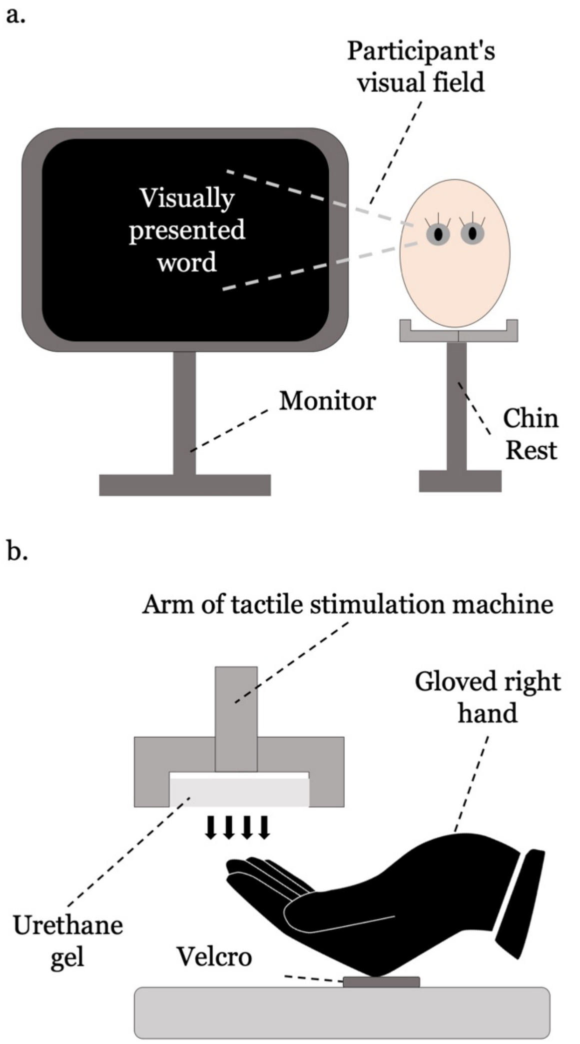

Figure 1. Experimental setup depicting visual stimuli presentation (a) and tactile stimuli presentation (b). Gloved hand clip art adapted from https://designdroide.com/cupped-hand-silhouette.html

Five practice trials were administered to the participants using a urethane gel and five words that were not used in the experiment, to ensure that the participants understood the instructions. Twenty-four experimental trials were then conducted. The visually presented words were pseudo-randomised such that words belonging to the same category (positive/neutral/negative) were never consecutively presented. In addition, tactile stimuli of the same category (soft/hard) were also never consecutively presented. On each trial, the machine lowered the respective urethane gel (set at a height of 90 mm) at a constant force of 5 N and a speed of 300 mm/min onto the participant's fingertips. Concurrently, the participants were asked to rate the valence of the corresponding visually presented word (rating range from 1 to 9) displayed on the monitor. Participants keyed-in response ratings with a USB-wired number pad placed in front of their left hand.

Reaction times and word valence ratings were recorded for each trial – by Neurobehavioral System's Presentation. Statistical analyses were conducted with IBM SPSS Statistics Version 24. The experimental session lasted about 30 min.

RESULTS

Two 2x3 repeated-measures ANOVAs were conducted to assess the effect of object compliance (tactile stimuli) on word valence (visually presented words) using (1) the participants' valence ratings and (2) the participants' reaction times.

The Object Compliance factor consisted of two levels – soft stimuli (gels H and I) and hard stimuli (gels A and B); the Word Valence factor consisted of three levels – positively valenced, neutrally valenced and negatively valenced.

ANOVA (Word Valence Rating)

According to Mauchly's test, the assumption of sphericity was violated for the main effect of word valence, $\chi^2(2) = 7.27$, $p = .026$. Therefore, the associated degree of freedom for the main effect of word valence was corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .78$).

The results highlighted a statistically significant main effect of Word Valence on the participants' ratings of the visually presented words $F(1.56, 35.89) = 175.12$, $p < .001$, $\eta_p^2 = .88$. Post-hoc pairwise comparisons conducted with the Bonferroni adjustment suggested that the average word ratings by the participants was significantly higher for positively valenced words ($M = 7.59$, $SD = 0.88$) than for neutrally valenced words ($M = 6.01$, $SD = 0.88$), $p < .001$ and negatively valenced words ($M = 3.04$, $SD = 0.88$) $p < .001$. Average word ratings by the participants were also significantly higher for neutrally valenced words than for the negatively valenced words, $p < .001$.

The main effect of Object Compliance and the interaction effect between Object Compliance and Word Valence was not statistically significant: $F(1, 23) = 0.85$, $p = .367$, $\eta_p^2 = .04$ and $F(2, 46) = 1.65$, $p = .202$, $\eta_p^2 = .07$ respectively.

ANOVA (Reaction Time)

Reaction times underwent the same 2x3 ANOVA. There was a statistically significant main effect of Object Compliance on the participants' word rating reaction time $F(1, 23) = 10.80$, $p = .003$, $\eta_p^2 = .32$; average reaction time for word ratings was significantly longer with soft stimuli ($M = 2.45$ s, $SD = 1.02$ s) than with hard stimuli ($M = 2.30$ s, $SD = 1.02$ s).

In addition, there was also a statistically significant main effect of Word Valence $F(2, 46) = 8.92$, $p < .001$, $\eta_p^2 = .28$. Post-hoc pairwise comparisons conducted with the Bonferroni adjustment suggested that the average reaction time for word ratings was significantly shorter for positively valenced words ($M = 2.24$ s, $SD = 1.02$ s) than for neutrally valenced words ($M = 2.42$ s, $SD = 1.02$ s), $p = .011$ and negatively valenced words ($M = 2.47$ s, $SD = 1.02$ s), $p < .001$. Average reaction time for word ratings were not significantly shorter for neutrally valenced words than for the negatively valenced words, $p = .989$.

The interaction effect between Object Compliance and Word Valence was not statistically significant, $F(2, 46) = 0.43$, $p = .653$, $\eta_p^2 = .02$.

DISCUSSION

In the present study, we observed that the valence of the visually presented words affected the speed at which participants rated the words, with negatively valenced words rated the slowest. We posit that this difference in the speed of rating could be attributed to the greater interference effects caused by negative words (Nasrallah, Carmel & Lavie, 2009). Work by McKenna and Sharma (1995) demonstrated this effect in a set of emotional Stroop tasks. Neuroimaging studies on individuals with unipolar major depressive disorder have also corroborated this finding (Mitterschiffthaler et al., 2008). Evidence points towards the adaptive advantage of unintentional hyperattention to stimuli that may result in undesirable/negative affect, in what has been termed automatic vigilance by Pratto and John (1991). However it must be noted that the generalisability of words to other affective stimuli have been called into question (Schimmack, 2005). Future adaptations of the present study may seek to use affective pictorial stimuli (see IAPS; Bradley & Lang, 2007) instead of words.

The present study did not find a statistically significant interaction effect between the Object Compliance and Word Valence on both the participants' word valence rating and the time taken to make said rating. This result is largely congruent with the findings by Suzuki and Gyoba (2008); as participants were not blindfolded in this experiment, it may be proposed that this lack of hedonic transfer (from touch to vision) could be similarly attributed to the differing affective sensitivity of touch and vision. They claim that this differing sensitivity stems from the fact that touch plays a more important role than vision in affective information as touch is both an exteroceptive and interoceptive sense while vision is only exteroceptive. However, the two studies have two key differences: (1) the touch condition in Suzuki and Gyoba's study involved haptic touch while the present study relied on passive touch and (2) while participants of the Suzuki and Gyoba study had contact with the tactile stimuli for 30 seconds, on average, participants of the present study provided their ratings 2.37 s after the gel touched their hand – clearly there is a difference in contact time with the tactile stimuli.

Therefore, even though Suzuki and Gyoba's interpretation is a fitting explanation for the lack of an interaction effect in the present study, fundamentally different mechanisms are at play for different durations in both studies. Thus, we propose the Maximum Likelihood Estimation (MLE) account of multisensory integration as an alternative explanation for the lack of an interaction effect. The MLE account of multisensory integration originally proposed by Ernst and Banks (2002), posits that the "lowest variance (i.e., noise) in a person's estimate regarding certain qualities of a given stimulus is the one that will likely 'dominate' or 'drive' perception over the inputs provided by the other sensory modalities" (Spence & Gallace, 2011, p. 275).

As the visually presented words were rated in line with the normative emotional ratings established by the ANEW (i.e. positively valenced words rated more positively than both neutrally valenced and negatively valenced words), this may signify minimal ambiguity in interpretation and a less noisy estimate of valence. Given that participants were also explicitly instructed to maintain attention on the visually presented words, the visual stimuli could very well have had the less noisy estimate of valence. As a result, the estimate of valence of the visually presented words may have dominated than that of the tactile stimuli, explaining the lack of an interaction effect.

That being said, this MLE account does not seem to adequately address the present study's findings that participants took longer to rate the visually presented words when presented with soft stimuli. According to the MLE account, tactile stimuli should have no effect on visual stimuli. Clearly, an alternative approach is needed to better understand what we consider to be the present study's key finding. We propose that the soft material disrupted the attention of the participants, resulting in a longer time taken to rate the visually presented words.

What is so special about positive words? Over the years, researchers have strived to answer this question with emotional Stroop tasks. In this task, participants are instructed to ignore the emotional content of the different presented words and name the ink colour that the words are printed on as quickly as possible (Strauss & Allen, 2006). A set of emotional Stroop tasks by Martin, Williams and Clark (1991) showed that in a clinically anxious population, positive words were colour-named significantly slower than neutral words. In what was dubbed the emotionality hypothesis, the authors highlighted that positive words were just as disruptive to the attention of clinically anxious individuals as negative threatening words. While this finding is not very generalisable and has been consistently refuted by aforementioned work on negative interference effects, an emotional Stroop task study by Strauss and Allen (2006) found that non-clinical participants experiencing higher levels of momentary (state) positive emotions took longer to process positive, happiness-related words. Considering the finding that soft tactile stimuli engenders pleasantness (unpublished results obtained in our lab), it could be that the presentation of soft stimuli in the present study created a momentary positive emotional state that disrupted the attention of the participants (attention bias), resulting in slower ratings of the visually presented words, regardless of their valence.

Although Strauss and Allen's (2006) unisensory study (visual) highlighted that this effect of state positive emotions is specific to positive words only, we argue that this difference in results could be attributed to the present study's multisensory design. Put differently, we propose that the same mechanism of state positive emotion and attentional bias suggested by Strauss and Allen could be at play in the present experiment; however, we hypothesise that the disruption of attention caused by the soft tactile stimuli will slow down the time taken to rate the visually presented words regardless of their valence, due to the study's unique integration of touch and vision.

By extension, if our hypothesis is valid, this disruption of attention by the soft tactile stimuli should also slow down the time taken to make judgements of visually presented words that do not require evaluations of valence. In other words, we suggest that in multisensory interactions between touch and vision, the disruption of attention is contingent on the presentation of soft tactile stimuli.

PROPOSAL: EXPERIMENT 2

In order to empirically assess our claim that the disruption of attention is contingent on the presentation of soft tactile stimuli in multisensory interactions of touch and vision, we propose a second experiment, Experiment 2

To ensure comparability, Experiment 2 will still assess the multisensory interaction of touch and vision but with a high-level cognitive task not involving emotion (unlike the one in Experiment 1). Specifically, participants of Experiment 2 will rate the level of abstractness of the same set of 24 visually presented words, while they are presented with the same four tactile urethane gels.

Experiment 2 will involve the same factor of Object Compliance as in Experiment 1 – soft stimuli (gels H and I) and hard stimuli (gels A and B). On the other hand, the Word Valence factor will be replaced with the three-level Word Abstractness factor – high abstractness, average abstractness and low abstractness. The basal abstractness level of the 24 visually presented words will be determined by a pilot experiment. Methodologically, apart from the instructions given, the experimental setup and procedure of Experiment 1 will be maintained.

If our idea that presenting soft tactile stimuli is disruptive to attention and will increase time taken to make judgements regardless of task (emotional or non-emotional related) holds, we should expect to see a main effect of object compliance on the time taken to rate the abstractness of the visually presented words. Specifically, the average time taken to rate the abstractness of the visually presented words should be longer when presented with soft tactile stimuli than with hard tactile stimuli.

CONCLUSION

The present study found that compared to hard tactile stimuli, the presentation of soft tactile stimuli led to a longer time taken to rate the valence of visually presented words. In this paper, we proposed that due to the multisensory nature of this study, the disruption of attention could have been created by the presentation of soft tactile stimuli.

However, it should be noted that we are unable to rule out the effect of contingent emotions on participants' time taken to rate the valence of words during the experimental trials. Future studies should consider administering psychometric questionnaires to assess the participants' state emotions before and after the experimental trials.

Further, future studies may also consider using different validated affective word sets to replicate

Experiment 1 and to test Experiment 2. While Experiment 2 was designed to be an exact replication of Experiment 1, we acknowledge that due to the way the 24 words were originally selected, some words may be emotionally charged. Though Experiment 2's proposed instructions were framed to focus the participants' attention on the semantic qualities (i.e. abstractness) of the words, these emotionally charged words may skew their evaluations.

To reiterate what was previously mentioned, future adaptations of the present study may also consider using affective pictorial stimuli (e.g. IAPS) to further validate our assertion that in multisensory interactions between touch and vision, the disruption of attention is contingent on the presentation of soft tactile stimuli.

Lastly, even though the present study did not find a statistically significant interaction effect between Object Compliance and Word Valence on the participants' word valence ratings and the time taken to make said rating, computational modelling methods may elucidate the intricacies of multisensory interactions between touch and vision in the affective domain. A better understanding of these interactions (or lack thereof) may explain why the present study's findings differ from that of Strauss and Allen's (2006) unimodal study.

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