ISSN 1512-1801

A SEMANTIC APPROACH TO CROSSMODAL PHENOMENA

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Abstract

The aim of this contribution is to introduce a possible foundation for a semantic approach to crossmodal phenomena. Crossmodality refers to cognitive processes that integrate two or more senses, like hearing and tasting, or seeing and touching. The main argument of this contribution states that all crossmodal phenomena can be explained conceptually or lexically, that is, semantically. It is argued that a search for meaning conducts the integration of information provided by different senses. Two sets of predictions can be derived from this view of crossmodality. First, the conceptual proximity between information obtained from different senses can explain both facilitation and interference. Second, the lexical proximity can also explain facilitation and inference in some cases. The switch from the conceptual criteria to the lexical criteria might be concerned with difficulty. That is, when the experimental task is more difficult, the lexical processing might be activated. Contrarily, when the task is less difficult, the conceptual processing might be activated. Difficulty might be operationally defined by the amount of information given and time restrictions. More information and less time shall produce more difficult tasks than the opposite condition. The coherence between the semantic approach and several well documented crossmodal phenomena are discussed.

Keywords

Crossmodality-memory-facilitation-semantics-cognition-Stroop

Introduction

Imagine a single malt *connoisseur*. She or he goes to an expert seller, walks through the aisle, sees the colours, smells the wood of the shelf and hears the ambient music. A simultaneous set of information arrives to the cognitive system of the *connoisseur*. Visual, olfactory, auditive, and tactile perceptions need to be integrated in working memory [1,2]. That is, active representation of multiple senses must be taken together to construct a complex meaning concerned with single malt products. If the *connoisseur* can also taste the malts, crucial gustative information needs to be integrated in working memory [3]

Nowadays, the crossmodal research field is concerned with such integrative cognitive processes [4,5]. Both theory and experiments are concerned with perceptual and memory processing [6]. Two main phenomena are often studied, that is, facilitation and interference, both concerned with response type and response time [7,8]. Facilitation occurs when correct response rates increase and response time measures decrease. Interference occurs when the opposite happens, that is, when correct response rates decrease and response time measures increase. Crossmodal facilitation means that the multiple sensory system worked better and faster in human memory [9,10]. Crossmodal interference means that such system worded worse and slower. This might happen for any combination of senses and attributes. For example, in several experiments the gustative recognition of a banana increased the correct response rates and decreased the response time measures when the gustative stimulus was administered simultaneously with a yellow visual

ISSN 1512-1801

stimulus [6,7]. Contrarily, a significant interference was observed when the same gustative stimuli was simultaneously presented with a red visual stimulus.
Crossmodal consistency can be understood as the convergence of expected perceptions concerning specific objects [11]. For example, when the taste of a tomato -gustative stimulus- and the red colour of the tomato -visual stimulus- are simultaneously processed in the working memory. Inconsistency can be understood as a discrepancy between perceptual information obtained from different senses. For example, the taste of a tomato and a blue colour. Consistency predicts facilitation, while inconsistency predicts interference in working memory [6,7,11].
A prominent research tradition in human cognition postulated several decades ago a duality in the human mind [12,13,14,15]. Intuition and reflection in reasoning [16], fast and slow processes in decision making [15], top-down and bottom-up inferences in perception [17], and so on. Some authors like Kahneman [15] often use terms like system 1 and system 2 to describe such duality, where system 1 is intuitive and system 2 is reflective [18]. It is proposed in this contribution that crossmodal phenomena can also be described according to such duality. It is argued that well known crossmodal patterns can be explained as semantic phenomena [11] that activate system 1 or system 2. Crossmodal processing of system 1 might be related to fast responses based on lexical criteria [19]. Crossmodal processing of system 2 might be activated based on conceptual criteria. It is argued that the switch between system 1 and system 2 might be concerned with task difficulty. Information amount and time restrictions might be relevant to define such difficulty [13,19].
This contribution continues as follows. First, we review the main discoveries concerned with crossmodal phenomena. Then, we outline a semantic approach to crossmodality [20]. Then, we derive some predictions from our semantic view of facilitation and interference between different senses in working memory. Finally, we discuss our proposal and suggest further developments.

Main Crossmodal Phenomena

The most prominent and influential crossmodal phenomenon is the Stroop task typical response pattern [21,22,23]. Briefly described, the Stroop task requires to mention the colour of the ink used to write a word presented on a screen [18]. Simultenaously, such word refers to a colour. When the ink and the word are consistently referred to the same colour a facilitation phenomenon is expected. That is, a faster response and higher correct response rates have been observed. Consistency predicts facilitation. Contrarily, when the ink and the word are inconsistent, responses become slower and correct response rates become less frequent. Inconsistency predicts interference in the Stroop task [24,25].
We argue that such behaviour patterns can be described as semantic phenomena [11,20]. That is, system 1 might be responsible for lexical responses and system 2 might be activated when conceptual responses are found. A lexical processing is shallower than a conceptual processing. Therefore, incorrect responses shall be faster and less working memory consuming. By the opposite, correct responses -conceptual match between task and response- shall consume more time. Several varieties of Stroop-task-like experiments have been conducted in the crossmodal research field [26]. The same results have been found between tasting and seeing, between tasting and hearing, between touching and seeing, between touching and hearing, between seeing and smelling, among other pairs. That is, the alternative activation of system 1 or system 2 might be considered as a generalized phenomenon. Therefore, facilitation and interference between different senses might be attributed to a higher level cognitive criterion. We suggest that such criterion is semantic, that is, the search for meaning based on sensorial information.

A Semantic Approach

Semantics can be understood as a branch of linguistics concerned with meaning [11,27,28,29]. Nowadays, two main subfields can be identified within semantics, that is, a lexical field and a conceptual field [11]. The former is concerned with the surface of the words, that is with the letters and associated attributes of words. The latter is concerned with concepts, that is, with the definition of such words. A historical perspective that can be found in authors like Frege [30,31] distinguish

ISSN 1512-1801

between sense and reference concerning the meaning of concepts. According to Frege, the concept *stricto sensu* refers to specific objects, not to abstract attributes. That is, he promotes an extensional meaning of concepts. The intensional meaning remains weaker than the extensional meaning according to Frege. However, such distinctions are logical rather than psychological. That is, from a psychological perspective, sense might have preeminence over reference [31]. A similar phenomenon occurs in poetry according to Frege. In other words, system 1 might be activated before system 2. A lexical and fast response might be automatically triggered, while a conceptual response might require to stop system 1 and to activate a deeper processing concerned with reference [12].

Since the visual response is more automatic than other senses, Stroop-like-task experiments can be considered difficult. This is so because a lexical response can be expected. System 1 has to be stopped to generate a conceptual response generated by system 2. In other words, difficulty reduction might be the shift that deactivates system 1 to activate system 2. The lexical response might switch to system 2 under such condition. A shallower lexical process has to be stopped to promote a deeper conceptual process.

A possible theoretical foundation for these response patterns might be concerned with Frege´s distinction between intension and extension in meaning [31]. Extensional meaning, that is enumeration of the objects included in a specific concept, is the proper concept. By the opposite, a single case of the concept does not satisfy meaning. Such phenomenon remains as sense, but not as reference. Sense is a shallower version of meaning when compared to reference. That is, a translation of Frege´s philosophy to current cognitive science might state that system 1 has to be only a step towards system 2. Such shift occurs when experimental subjects can arrive to a correct response, which is facilitated under consistency and obstructed under inconsistency between senses.

From Frege [30,31] to current cognitive science [12,13], a theoretical bridge can be identified concerning crossmodality [11]. A conceptual processing is preferred than a lexical processing [8]. System 2 is preferred than system 1. Such shift avoids interference and promotes facilitation.

Predictions

The main prediction states that crossmodal phenomena are semantically driven, that is, concept is a better predictors than lexical aspects. In other words, consistency is a deep conceptual matter rather than a shallow lexical matter. It is inferred that a stroger interference can be predicted when the contradiction occurs between lexical and conceptual aspects. A weaker interference can be predicted when contradiction occurs between lexical aspecs only.

If this proposal is correct, concepts are more important than their perceptual divergencies. That is, faster response times and higher correct response rates can be predicted when conceptual consistency is preserved. Moreover, the proposal can be refuted if the controlled experimental evidence shows that concepual inconsistency promotes facilitation and conceptual consistency promotes interference.

For example, a lower music tone -auditive sense- migh be faster recognized as bitter than acid -gustative sense-. By the opposite, a higher music tone -auditive sense- might be faster recognized as acid than bitter -gustative sense-. This might occur because both, the lower tone of music, and the bitter taste, belong to the same superordinate category, sadness for example. In the same line of reasoning, the category of happiness might be associated to higher music tone and acid gustative stimuli. That is, such lexical attributes migh be subordiantes of the superordinate meaning of happiness.

This semantic approach of crossmodal phenomena can be refuted if the experimental evidence shows that conceptual consistency leads to interference and conceptual inconsistency leads to facilitation.

ISSN 1512-1801

Discussion

We argue that the state-of-the-art in the psychology of crossmodal phenomena requires a semantic approch to account for previous findings and predict further response patterns [11]. We accounted for Stroop-task and Stroop-like-task experiments using theoretical resources derived from Frege´s classical proposals [30,31] and recent cognitive linguistics [20]. Our semantic view states that crossmodal phenomena are a matter of concepts, rather than lexical processes. However, a lexical system might be automatically activated since crossmodal tasks are typically difficult. That is, working memory load and time restrictions are structural components of crossmodal experimental tasks like Stroop-like studies [21,27,28]. The integration of two or more senses seems to be a hard task [9]. Hence, a lexical process might be spontaneously activated [29]. The result generated by such shallow process is a wrong response or a slower response. That is, the lexical response might be understood as an interference phenomenon. By the opposite, a deeper conceptual process concerned with extensional meaning might promote correct responses in Stroop-like-task experiments. System 1 seems to deal with shallow aspects of meaning. System 2 seems to deal with deeper or conceptual aspects of meaning [15,18,20].

This approach is consistent with the accumulated evidence concerned with crossmodal phenomena. That is, it explains facilitation and inference as functions of difficulty in working memory [2]. Harder tasks seem to promote interference activated by a shallow processing of sensorial information. Easier tasks -performed by system 2- seem to promote facilitation. Hence, conceptual consistency seems to be at the core of crossmodal phenomena.

A similar situation occurs in the field of reasoning research. System 1 or intuitive responses in hard reasoning tasks lead to a *matching bias* phenomenon [19]. That is, hard compound negation tasks promote lexical driven responses. When negation tasks are less difficult, a deeper conceptual processing seems to occur and higher correct response rates are obtained. Concepts seem to be crucial both for reasoning tasks and crossmodal integration phenomena.

To our knowledge, no evicence has been reported that contradicts a semantic approach to crossmodal cogition [11].

Conclusions

The inspection of the current state of knowledge concerning crossmodal phenomena suggests that: 1) A dual system approach seems to be consistent with the crossmodal research field. 2) Facilitation and inference seem to be related to the activation of two different cognitive systems, lexical and conceptual, respectively. The switch between the former and the latter might operate on the basis of task difficulty. Memory load and time restrictions might contribute to such difficulty. 3) A specific research agenda can be derived from the proposed semantic view of crossmodality. 4) Further predictions can be derived from the semantic account of crossmodal phenomena, but also the key aspects of its refutation were explicitly stated in this contribution.

A single malt *connoisseur* in a scotch whiskey shop seems to behave like a semantic cognitive agent rather than a pure sensorial one. We argue that crossmodality is a matter of meaning. The integration of senses might be better understood as a conceptual process, rather than a restricted sensorial process.

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ISSN 1512-1801

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ISSN 1512-1801

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Article received 2020-10-30