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Article *in* International Journal of Cognitive Informatics and Natural Intelligence · April 2014

DOI: 10.4018/IJCINI.2014040103

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Fuzzy Causal Patterns of Humor and Jokes for Cognitive and Affective Computing

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ABSTRACT

Humor is an advanced emotional and cognitive ability of mankind that involves complex semantic inference and deep passionate appreciation. This paper presents the cognitive foundations of amusement and a general theory of humor based on the recent advances in cognitive informatics, cognitive linguistics, cognitive computing, and fuzzy causal analyses. A theory of fuzzy false causation (FFC) is introduced that reveals humor and jokes as false causations in fuzzy causal inferences. Base on the FFC theory, a general pattern of humor (GPH) is formalized for analyzing the settings and appreciations of a set of sample jokes. A formal measurement of the degree of amusement in jokes and humor is quantitatively described towards the rational explanation of jokes based on cognitive affective assessment. The formal models of humor and jokes enable machines for humor comprehension and appreciation in artificial intelligence, cognitive computing, computational intelligence, and cognitive robots.

Keywords: *Artificial Intelligence, Cognitive Computing, Cognitive Informatics, Cognitive Robots, Computational Intelligence, False Causation, Formal Inference, Fuzzy Models,, General Pattern Of Humor, Humor, Humor Appreciation, Jokes, Measurement Of Amusement*

1. INTRODUCTION

Humor and jokes, as well as their comprehension and appreciation, are a special and advanced emotional and cognitive ability of humans that involves complex semantic inferences and deep passionate cognitions. Humor and jokes have been studied since the early phase of human civilization as a curious mental phenomenon. Studies on humor and jokes can be traced back to Aristotle`s era where humor was perceived as a comparison between a noble and ignoble person, thing, or behavior in about 330 B.C. (Aristotle 1989; Hurley et al. 2011). Darwin has compared the similarity between the pair of humor and laughter with the pair of tickling and laughter in 1872, which led to the Darwin-Hecker hypothesis of the play metaphor on humor (Darwin 1872; Hecker 1873). Descartes expressed that humor is a mixture of joy and shock in 1649 (Descartes 1649). Since then, scientific studies on humor and jokes have attracted a wide range of interests in philosophy, psychology, linguistics, cognitive science, brain science, sociology, artificial intelligence, cognitive informatics, and affective computing.

A number of categories of metaphors and hypotheses of humor have been developed

DOI: 10.4018/IJCINI.2014040103

such as those of the superiority, surprise, play, incongruity, relief, and semantics metaphors (Minsky 1984; Raskin 1985; Attardo 1994; Ritchie 2001, 2004; Martin 2006; Mihalcea and Strapparava 2006; Hurley et al. 2011; Wang, 2013a). The *superiority* metaphor of humor (Hobbes 1840) describes the comparative aspect of humor by pointing out unrealized problem, mistake, and imperfectness of states, behaviors, or appearance. The *surprise* metaphor of humor describes that the cause of humor is an effect of an unanticipated occurrence of an event. The *play* metaphor of humor considers the biological link between tickling stimuli and laughter where a play is extended from physical to physiological stimuli known as the Darwin-Hecker hypothesis (Darwin 1872; Hecker 1973; Gervais and Wilson, 2005). The *incongruity* metaphor of humor describes a pattern where reasons gone mad (Marx, 2009) by incongruous setting resolved subsequently. The *relief* metaphor of humor describes humor as a releasing process of an emotional tension that causes funny behaviors (Spencer 1860). The *semantics* metaphor of humor is proposed in recent years towards the conceptual models of jokes using *ontology* (Raskin 1985; Wang, 2013a; Taylor and Raskin 2013), *concept algebra* (Wang, 2008, 2011; Tian et al. 2009; Lin & Wang, 2014), *semantic algebra* (Wang 2012b, 2013a), as well as cognitive informatics and cognitive computing (Wang 2002, 2003, 2013b, 2013c, 2014c; Wang & Berwick 2013; Wang & Tian, 2013; Wang et al. 2013).

The sense of humor is one of the origins of human passion and emotions that classifies certain external stimuli into the categories of pleasant or unpleasant. Amusement has direct connection to the deep root cognition and perceptual senses of humans such as emotions, passions, motivations, attitudes, perceptions, and causal inferences.

Definition 1: *Humor* is affective and pleasant effect expressed in human communication that stimulates amusement, jocularity, fun, and laughter.

Humor can be expressed or affected in multiple ways by multiple means to affect the receivers. Humor triggers both laughter and the sense of amusement.

Definition 2: *Amusement* is a basic cognitive state that reflects the recognition of a pleasant event in situation comprehension or a joyful surprise of a misleading causation in thought and inference.

The biological and neurophysiological foundation of the sense of humor is based on the sensory of tickle and stroke stimuli in a peaceful and pleasant environment. The tickle sense is developed in the early phase of lives of infants during interactions with parents and friends. Laughter is a state of passion that expresses pleasant, friendship, and safeness. People share laughter will get closer in a pleasant atmosphere. Therefore, humor and amusement are deeply existed at the root of human emotions and perceptions so that every baby has a funny bone.

Definition 3: A *joke* is a humor expressed in languages or behavior.

Humor making and appreciation are a creative process that exercises the wit sense of humans in an amusing manor. From this point of view, joke and wit are a special creativity that generates novel cross words with ambiguous semantics where the true causation is hidden for realization.

This paper presents the cognitive foundations of amusement and a general theory of humor and jokes based on recent advances in cognitive informatics, cognitive linguistics, cognitive computing, and fuzzy causal analyses. A theory of fuzzy false causality is presented that reveals humor and jokes as misleading causations in human reasoning. In the remainder of this paper, the fuzzy false causation model of humor and jokes is formally described in Section 2, which reveals the nature of humor and its general patter in natural languages. Base on the fuzzy false causation theory, a general pattern

of humor (GPH) is introduced. The cognition and appreciation of fuzzy false causations are demonstrated in Section 3 by a set of randomly selected sample jokes. A formal measurement of amusement of jokes and humor is established in Section 4 in order to rigorously assess the impact and degree of amusement based on cognitive and affective testing. This work provides formal models for machine-enabled humor inference and comprehension in artificial intelligence, cognitive computing, cognitive robots, and computational intelligence.

2. THE GENERAL PATTERN AND FORMAL MODEL OF HUMOR AND JOKES

Humor is the way in which people see that some things are amusing or the ability to be amused by things. A joke is a story or trick that is said or done in order to make people laugh. Humor and jokes are an interesting phenomenon in human causal reasoning and perception that results in an amusing false causality and a pleasant surprise.

2.1. Humor Appreciation and Causal Inference

Inferences are a cognitive process that reasons a possible causation from given premises between a pair of cause and effect. Causal inference is one of the central capabilities of human brains, which plays a crucial role in thinking, perception, reasoning, and problem solving (Zadeh 1965, 1975, 2006; Martin 2006; Attardo 1994; Sternberg 1998; Wang 2003, 2007, 2012a, 2013a, 2014a, 2014b; Wang et al. 2009). A causal inference can be conducted based on empirical observations, formal reasoning, and/or statistical norms (Zadeh 1975; Wang 2007, 2012b, 2013a; Wilson and Keil 2001).

Definition 4: Let $\mathfrak{S}$ be a finite nonempty set of *states* or facts, R be a finite set of *relations* between a pair of states. The *discourse of causality* $\mathfrak{U}$ is a 2-tuple, i.e.:

$$\mathfrak{U} \triangleq (\mathfrak{S}, \mathfrak{R}) \tag{1}$$

where R is a Cartesian product between $\mathfrak{S}$ s, i.e., $\mathfrak{R} = \mathfrak{S} \times \mathfrak{S}$.

On the basis of the causal discourse, a *causation* is a relation of a logical consequence between a sole or multiple causes and a single or multiple effects. A causation is usually a pair of (*Cause, Effect*). Causal relations may be 1-1, 1-*n*, *n*-1, and *n*-*m*, where *n* and *m* are integers greater than 1 for multiple relations. The *cause* (C) in a causation in $\mathfrak{U}$ is a premise state such as an event, phenomenon, action, behavior, or existence. Related to the cause, a *reason* is a premise of an argument in support of a belief or causation. However, the *effect* (E) in a causation in $\mathfrak{U}$ is a consequent or conclusive state such as an event, phenomenon, action, behavior, or existence.

Definition 5: A *fuzzy set* $\widetilde{S}$ in the universal causal discourse $\mathfrak{U}$ is a special set in which each element is a pair with an element x and the weight of its degree of membership, w_x, in the given set, i.e.:

$$\widetilde{S} \triangleq \{(x, w_x) \mid w_x = \mu_{\widetilde{S}}(x) = f : x \to \mathbb{I},\ \mathbb{I} \in (0,1]\} \tag{2}$$

where w_x is determined by the membership function $\mu_{\widetilde{S}}(x)$ in the domain $(0, 1]$, and $\mu_{\widetilde{S}}(x)$ is application case dependent.

On the basis of fuzzy set, traditional logical inferences can be extended to fuzzy inferences where the premises of reasoning become fuzzy expressions rather than Boolean ones in traditional logical inferences.

Definition 6: A *fuzzy causation* ξ, $\xi \in \mathfrak{R}$, in $\mathfrak{U}$ is a relation that maps a nonempty fuzzy set of causes $\widetilde{C}$ into a nonempty fuzzy set of effects $\widetilde{E}$, i.e.:

$$\xi \triangleq f_{\xi} : \widetilde{C} \to \widetilde{E},\ \xi \in \mathfrak{R}, \widetilde{C} \subseteq \mathfrak{S}, \widetilde{E} \subseteq \mathfrak{S} \quad (3)$$

On the basis of the formal fuzzy causation ξ in $\mathfrak{U}$, an inference becomes a cognitive process that deduces a conclusion, particularly a causation, according to logical rules and known evidences.

Definition 7: A *fuzzy inference* $\widetilde{\kappa_b}$ in $\mathfrak{U}$ is a cognitive process that deduces a fuzzy causation ξ between a set of fuzzy causes $\widetilde{C}$ and a set of fuzzy effects $\widetilde{E}$ denoted by $\vdash$, i.e.:

$$\begin{aligned} \widetilde{\kappa} &\triangleq \widetilde{C} \vdash \widetilde{E} \\ &= C \vdash f_{\xi}(C) \end{aligned} \quad (4)$$

where $\vdash$ reads *turnstile* and the term *reasoning* is treated as a synonym of inference.

Conventional methods for inference and reasoning are such as relational, logical, functional, rule-based, neural networks, concept algebra, Bayesian networks, and causal networks. Fuzzy inferences are powerful denotational mathematical means for rigorously dealing with degrees of matters, uncertainties, and vague semantics of linguistic entities, as well as for precisely reasoning the semantics of fuzzy causations. Typical fuzzy inferences are known as *fuzzy argument, deductive, inductive, abductive,* and *analogical* inferences (Zedeh 2008; Wang 2012b).

2.2. The General Pattern of Humor and Jokes

Definition 8: The *essence* of humor or jokes is a *fuzzy false causation* (FFC) on a setting of fuzzy semantic ambiguities that causes an amusing surprise when it is realized.

There are three essential factors constituting humor which are: (i) The *reason*: a semantic ambiguity; (ii) The *process*: a false causation; and (iii) The *effect* (result): the revealing of an amusing surprise. Therefore, humor or jokes can be formally described in the following theorem.

Theorem 1: The *general pattern of humor* (GPH), $\mathfrak{J}$, is a false causal inference process, $\tilde{c} \vdash_{\mathrm{F}} e'$, which is yielded by the semantic ambiguity of a fuzzy cause $\tilde{c}$, that reveals an amusement surprise,:), when the true causation $\tilde{c} \vdash_{\mathrm{T}} e$ is realized, i.e.:

$$\mathfrak{J} \triangleq \exists \widetilde{c},\ \widetilde{c} \left\langle \begin{matrix} \vdash_{\mathrm{F}} e' \to \\ \vdash_{\mathrm{T}} e \to \end{matrix} \right\rangle \oplus \Rightarrow \ :) \quad (5)$$

where e and e' are precise effects that are a special case of a fuzzy effect, and $\vdash_{\mathrm{T}}$ and $\vdash_{\mathrm{F}}$ denote a true or false causation, respectively.

The formal model of humour and jokes, as given in Theorem 1, not only explains the nature and essences of human humor, but also enables machines to understand humor in natural languages in a rigorous approach. The mathematical model and the GPH pattern convey human amusing false causations to machines in order to allow the implied false causality in a joke to be understood and comprehended by intelligent and cognitive systems (Wang 2010; Wang and Wang 2006; Tian et al. 2009).

3. COGNITIVE APPRECIATION OF FUZZY FALSE CAUSATIONS IN JOKES

On the basis of the cognitive mechanism of fuzzy false causation (FFC) and the general pattern of humor (GPH) as presented in preceding section, a humor or joke in real-world can be explained as an instance of GPH. A set of ten sample jokes in various forms is analyzed in this section, which demonstrates a general fitness between the practical settings of jokes and the GPH theory.

Example 1: 'A linguistic philosopher in a lecture made the claim that although a double negative in English implies a positive meaning, there is no language in which a double positive implies a negative meaning. Responding to this statement, "Yeah, yeah," answered by anther philosopher in a dismissive tone.' (Hurkey et al.)

This joke causes laughter by an unexpected finding of a logical exception about a general claim. According to the GPH theory as described in Theorem 1, joke $\mathfrak{J}_1$ can be formally modeled as a false causation as follows where M is a modifier or logical variable, and $\neg, \equiv, \text{and } \not\equiv$ represent negative, always true, or always untrue, respectively.

$$\mathfrak{J}_1 \triangleq \forall\ modifiers\ M,\ \neg(\neg M) \equiv M$$
$$\rightarrow \left\langle \begin{array}{ll} \vdash_{\text{F}} \forall M,\ M \times M \not\equiv \neg M & \rightarrow \\ \vdash_{\text{T}} \exists M,\ M \times M = \neg M, & \rightarrow \\ \multicolumn{2}{c}{i.e., \text{"yeah, yeah?!"}} \end{array} \right\rangle \oplus \Rightarrow :)$$

Example 2: 'My dentist had just pulled out one of my teeth and had told me to rest for a while. I tried to say something, but my mouth was full of cotton wool. During his talking, my tongue was busy searching out the hole where the tooth had been. I suddenly felt very worried, but could not say anything. When the dentist at last removed the cotton wool from my mouth, I was able to tell him that he had pulled out the wrong tooth.' (L.G. Alexandra)

According to GPH, joke $\mathfrak{J}_2$ can be formally explained as a realized false causation as follows in Box 1.

Example 3: 'A doctor and a lawyer were talking at a party. Their conversation was constantly interrupted by people describing their ailments and asking the doctor for free medical advice. After an hour of this, the exasperated doctor asked the lawyer, "What do you do to stop people from asking you for legal advice when you're out of the office?" "I give it to them," replied the lawyer, "and then I send them a bill." The doctor was shocked, but agreed to give it a try. The next day, still feeling slightly guilty, the doctor prepared the bills. When he went to send them, he found a bill in his mailbox from the lawyer.' (Michael Kennard)

According to GPH, joke $\mathfrak{J}_3$ can be formally explained as a realized false causation as follows in Box 2.

Example 4: 'Last week I went to the theater. The play was very interesting. However, I did not enjoy it because a young man and a young woman were talking loudly behind me. I could not bear it and turned round. "I can't hear a word!" I said angrily. "It's none of your business," the young man said rudely. "This is a private conversation!" ' (L.G. Alexandra)

According to GPH, joke $\mathfrak{J}_4$ can be formally explained as a realized false causation as follows in Box 3.

Example 5. 'Two friends, A and B, were sleeping in a tent in the field during the night. Suddenly, in midnight, A was wakened up and asked: "I am worrying why there are so many stars in the sky?" B answered: "Don't worry, the sky is clear." "No," A yelled: "Where is the tent?" ' (Anonymous)

According to GPH, joke $\mathfrak{J}_5$ can be formally explained as a realized false causation as follows in Box 4.

Example 6: 'Jeremy made a speech at a wedding reception with Jenny, his six-year-old daughter. It was a great success for so many funny stories in the speech. However, as soon as he had finished, Jenny told him

Table 1. Measurement of the amusement levels of humor and jokes

No.	Quality		Long-Term Impact		Weighted Amusement ($\mathfrak{A} = AT(E+F)/4$) [1, 100]
	Impact of Amusing Stimulus (A) [1, 5]	Period of Lasting (T) [1, 5]	Effectiveness of Recall (E) [1, 5]	Frequency of Recall (F) [1, 5]	
1	5.0	4.5	4.5	5.0	85.5
2	4.0	4.0	4.0	4.0	51.2
3	4.0	4.0	3.5	3.5	44.8
4	3.5	4.0	3.0	3.0	33.6
5	4.0	3.5	3.5	3.5	39.2
6	4.0	3.5	3.5	3.0	36.4
7	3.5	3.0	3.0	3.0	25.2
8	4.0	4.0	4.0	4.0	51.2
9	4.5	4.5	4.0	4.0	64.8
10	5.0	4.5	4.5	4.0	76.5

she wanted to go home. On the way home, Jeremy asked Jenny why she was unhappy. She told him that she did not like to see so many people laughing at him!' (L.G. Alexandra)

According to GPH, joke $\mathfrak{J}_6$ can be formally explained as a realized false causation as follows in Box 5.

Example 7: 'A man *A* called his friend *B* for an emergent help during night. He said

Box 1.

$$\mathfrak{J}_2 \triangleq \exists \text{ A patient } P \text{ @ dental operation,}$$
$$\rightarrow \left\langle \begin{array}{l} \vdash_{\mathrm{F}} \text{Can't speak during dental operation } \models \text{normal } \rightarrow \\ \quad (i.e., P \text{ was not wish to } \rhd \text{speak}) \rightarrow \\ \vdash_{\mathrm{T}} \text{Can't tell an accsident when realized } \models \text{abnormal } \rightarrow \\ \quad (i.e., \text{A wrong tooth } \rhd \text{was pulled out}) \rightarrow \end{array} \right\rangle \oplus \Rightarrow \ :)$$

Box 2.

$$\mathfrak{J}_3 \triangleq \exists \text{ A lawyer and a doctor } D \text{ @ a party}$$
$$\text{where they were chating:}$$
$$\rightarrow \left\langle \begin{array}{l} \vdash_{\mathrm{F}} \text{The lawyer gave } D \text{ a friendely advice } \rightarrow \\ \vdash_{\mathrm{T}} \text{The lawyer charged } D \text{ for the chat } \rightarrow \end{array} \right\rangle \oplus \Rightarrow \ :)$$

Box 3.

$$\mathfrak{J}_4 \triangleq \exists\ A \text{ and a young couple @ a theater}$$
$$\text{while they are talking loudly during performance:}$$
$$\rightarrow \left\langle \begin{matrix} \vdash_{\mathrm{F}} A \text{ was thought to over hear the young couple's talk} & \rightarrow \\ \vdash_{\mathrm{T}} A \text{ was unnable to hear the players because their talk} & \rightarrow \end{matrix} \right\rangle \oplus \Rightarrow\ :)$$

on the phone that he got lost and needed a pick up. "Where are you?" *B* asked. "I am standing opposite the street of my house," *A* answered. "You were drunken gain!" *B* immediately realized.' (Anonymous)

According to GPH, joke $\mathfrak{J}_8$ can be formally explained as a realized false causation as follows in Box 7.

Example 9: 'A competitor opened two new grocery stores at each adjacent side of

Box 4.

$$\mathfrak{J}_5 \triangleq \exists\ A \wedge B \text{ in a tent @ night field}$$
$$\text{when } A \text{ wakened up and could see the sky without a cover:}$$
$$\rightarrow \left\langle \begin{matrix} \vdash_{\mathrm{F}} B \text{ thought: No warry because the sky is clear.} & \rightarrow \\ \vdash_{\mathrm{T}} A \text{ realized: The tent was dispered.} & \rightarrow \end{matrix} \right\rangle \oplus \Rightarrow\ :)$$

According to GPH, joke $\mathfrak{J}_7$ can be formally explained as a realized false causation as follows in Box 6.

Example 8: I used to sell furniture for a living. The trouble was, it was my own.' (Les Dawson)

a popular one, which named "The Best Store in Town" and "The Cheapest Store in Town," respectively. The owner of the old store immediately went to the fair competition office for filing a serious complaint. As a result, the owner of the popular store was suggested to replace his sign plate by a new one showing "Main Entrance." ' (Anonymous)

Box 5.

$$\mathfrak{J}_6 \triangleq \exists \text{ Jeremy (dad)} \wedge \text{Jenny (young daughter) @ a wedding}$$
$$\text{when Jeremy's jokes were successful but Jenny was unhappy:}$$
$$\rightarrow \left\langle \begin{matrix} \vdash_{\mathrm{F}} \text{Jeremy thought that Jenny didn't like his jokes} & \rightarrow \\ \vdash_{\mathrm{T}} \text{Jeremy realized that Jenny didn't like peaple laughing at him} & \rightarrow \end{matrix} \right\rangle \oplus \Rightarrow\ :)$$

Box 6.

$$\mathfrak{J}_7 \triangleq \exists\ A \text{ and } B \text{ @ mid night}$$
$$\text{while } A \text{ called } B \text{ for help:}$$
$$\rightarrow \left\langle \begin{matrix} \vdash_{\mathrm{F}} A \text{ got lost} & \rightarrow \\ \vdash_{\mathrm{T}} A \text{ was drunken gain!} & \rightarrow \end{matrix} \right\rangle \oplus \Rightarrow \ :)$$

Box 7.

$$\mathfrak{J}_5 \triangleq \exists\ \textit{Person}\ A \text{ who used to sell furniture for a living:}$$
$$\rightarrow \left\langle \begin{matrix} \vdash_{\mathrm{F}} A \text{ was a rich business man} & \rightarrow \\ \vdash_{\mathrm{T}} A \text{ was extremely poor because the furniture were his own} & \rightarrow \end{matrix} \right\rangle \oplus \Rightarrow \ :)$$

According to GPH, joke $\mathfrak{J}_9$ can be formally explained as a realized false causation as follows in Box 8.

Example 10: 'A girl started her first job at a primary school and was eager to make a good impression on the kids. When he noticed a boy standing all by himself during recess, while the other kids were playing football in the ground, he walked up to him and asked "Are you alright?"

The boy assured her everything was fine and the teacher left it at that. A few minutes later, however, she noticed that the boy was still standing alone and had not joined the others to play. Deciding to find out what was wrong this time, the teacher approached the boy again and said, "Hi, are you sure you're not feeling left out? Would you like me to be your friend?" The boy felt a little embarrassed, but after a little hesitation he said, "Maybe." Encouraged by her progress, the teacher asked, "Tell me, why are you standing here alone?" "Because," the boy said with clear exasperation in his voice, "I am the goalkeeper." ' (Bob Alice)

According to GPH, joke $\mathfrak{J}_{10}$ can be formally explained as a realized false causation as follows in Box 9.

It is noteworthy that, although the selected jokes analyzed in this section represent a set of samples across the conventional categories of humor such as in those of the superiority, surprise, play, incongruity, and release metaphors, all jokes fit the general pattern of GPH and the mathematical model as developed in Section 2. This indicates a rational approach to unify the

Box 8.

$$\mathfrak{J}_9 \triangleq \exists\ \text{A unfair businessman toke advantage from a popular store}$$
$$\text{by unfair sign plates:}$$
$$\rightarrow \left\langle \begin{matrix} \vdash_{\mathrm{F}} \text{A serious dispute was expected} & \rightarrow \\ \vdash_{\mathrm{T}} \text{The unfair owner helped other's business} & \rightarrow \end{matrix} \right\rangle \oplus \Rightarrow \ :)$$

Box 9.

$$\Im_{10} \triangleq \exists \text{ A young teacher} \wedge \text{a boy @ the football groud}$$
$$\text{where she eagerly wished to help the pity boy:}$$
$$\rightarrow \left\langle \begin{matrix} \vdash_{\mathrm{F}} \text{ She thought the boy is lonely on the football groud} \rightarrow \\ \vdash_{\mathrm{T}} \text{ She realized that the boy is a goalkeeper} \rightarrow \end{matrix} \right\rangle \oplus \Rightarrow \ :)$$

humor theories and to reveal the nature of humor and jokes based on the GPH theory.

4. FORMAL MEASUREMENT OF LEVEL OF AMUSEMENT IN HUMOR AND JOKES

It is recognized as a hard problem to rigorously assess how good a piece of humor or joke is, though individuals may feel it subjectively and differently. This section introduces a quantitative measurement of levels amusement of humor based on the abstract quality theory (Wang, 2007), where the selected jokes presented in Section 3 are used as the test cases for the formal model of relative amusement in humor and joke measurement.

4.1. The Mathematical Model for Humor Measurement

The impact of humor and jokes can be formally assessed on the basis of Wang's general quality theory of abstract entities and abstract systems such as human causational inference, software systems, and creative design artifacts.

Theorem 2: The *general quality Q of* an abstract system in general, and a mental causation in particular, is an integration of its functional utility $F(t)$ over the duration T in which it may lasting, i.e.:

$$Q = \int_0^T F(t)dt \quad [FHr]$$
$$= F \bullet T \qquad \text{when } F(t) \text{ is a constant} \tag{6}$$

Equation 6 indicates that the properties of the general quality of an abstract entity or system are as follows.

Corollary 1: The larger the functional utility $F(t)$ and its lasting duration T, the higher the general quality of the abstract entity or system.

Corollary 2: There is no quality when either the functional utility $F(t)$ or its lasting duration T is zero for any abstract entity or system.

According to the general quality theory as described in Theorem 2, the level of amusement of any humor or joke can be rigorously measured by applying Equation 6 in the following definition.

Definition 9: The *quality of humor* Q_h is a product of the *level of amusing stimuli*, A, and its *lasting period, T*, in terms of function-hour, i.e.:

$$Q_h \triangleq A \bullet T \tag{7}$$

Then, the weight of the *long term impact* of a joke is considered as a sum of its effectiveness and frequency of recalls that revoke the joke in a person's long-term memory.

Definition 10: The *impact of humor* P_h is a sum of the *effectiveness of recalls* E and the *frequency of recalls* F, i.e.:

$$P_h \triangleq E + F \tag{8}$$

Definition 11: The *level of amusement* of humor, $\mathfrak{A}$, is a product of its *quality* Q_h and its long-term impact P_h, i.e.:

$$\begin{aligned} \mathfrak{A} &\triangleq kQ_hP_h \\ &= \frac{1}{4} A\,T \bullet (E + F) \end{aligned} \tag{9}$$

where $\mathfrak{A}$ is unified to a relative unit interval [1, 100] by $k = 2.5$.

Equation 9 can be used to facilitate comparative analyses among humor and jokes as shown in the following subsection. Once each of the factors for the quality of humor and its long-term impact are estimated in a relative scope [1, 5], the level of amusement of humor will be quantitatively determined in the scope of [0, 100], as demonstrated in the following subsection.

4.2. Case Studies in Quantitative Analyses of Humor and Jokes

A set of empirical assessment of the ten sample jokes as presented in Section 3 is obtained from the feedback of a group of graduate students as summarized in Table 1. According to the measurement model of humor and jokes as given in Equation 9, the levels of amusement for the set of jokes are quantitatively assessed in Table 1, which provide a objective analysis of humor and jokes by considering their relative impacts and lasting periods, as well as effectiveness and frequencies of recalls.

The psychological evaluation experiments demonstrate that the inherent quality and impact of a joke can be rigorously discriminated based on the measurement models as developed in Section 4.1. Therefore, the measurement model (Equation 9) can be used as a general method for assessing the degree of amusement as conveyed in humor and jokes, which is correlatively proportional to the laughter expected from the audience. Similarly, the measurement model of humor may be applied in the quantitative assessment of effects of cross talks, comedies, caricatures, and amusing performance. It can also be used to elicit statistical norms of humor and jokes among social groups.

5. CONCLUSION

It has been recognized in this paper that humor and jokes are not only an untravail social phenomena for laughing that is deeply related to human passionate appreciation, but also an advanced emotional ability of humans that involves complex cognitive mental processes. The cognitive foundations of amusement expressed in humor and jokes have been explored, which reveals humor as an abstract and reflexive conditioning between a false causation and realized amusement that result in laughter. On the basis of the cognitive foundations, a theory of humor and jokes known as *false fuzzy causation* (FFC) has been developed, which led to the *general pattern of humor* (GPH) for analyzing and explaining the mental cognition and appreciation of a variety of jokes. A formal measurement of the degree of amusement in jokes and humor has been presented towards the quantitative assessment of jokes based on cognitive affective testing in social groups. This work has not only explained the cognitive foundations and general patterns of humor creation and appreciation, but also presented a formal approach towards machine-enabled humor comprehension in artificial intelligence, cognitive computing, cognitive robotics, and computational intelligence.

ACKNOWLEDGMENT

This work is supported in part by a discovery fund granted by the Natural Sciences and Engineering Research Council of Canada (NSERC).

The author would like to thank the anonymous reviewers for their valuable comments on the previous version of this paper.

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